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JENNIE IN AN EFFECTIVE POSE.

THE SILVERTIP GRIZZLY PRESENTED BY THE ENGINEERS' CLUB TO THE BRONX ZOO.

TWO GENTLEMANLY EUROPEAN BROWN BEARS IN THE BRONX PARK ZOO.

THE TIBETAN YAK IN THE CENTRAL PARK COLLECTION.

HARD TRAVELING FOR THE ELEPHANT IN BRONX PARK.

HATTIE PERFORMING ONE OF HER DIFFICULT TRICKS.

WILD ANIMALS IN CAPTIVITY.—[SEE PAGE 39]

GUNCOTTON AND ITS MANUFACTURE.*

AN ACCOUNT OF MODERN METHODS.

BY COL. SIR FREDERIC L. NATHAN, R.A.

Concluded from Supplement No. 1749, page 19.

DIRECT DIPPING.

The first attempt attended with any success to overcome some of the disadvantages of the Abel process was the introduction of what is known as the direct dipping process. This system was used on a large scale at Nobel's factory at Ardeer, in Scotland, and I am indebted to the kindness of Mr. Lundholm for a description of it, of which the following is an abstract:

The installation consists of parallel double rows of long iron tanks known as "coolers." Iron pots termed "dippers," in which nitration is carried out, stand in the coolers, 62 to each cooler. Sliding wooden covers rest on the coolers to guide the fumes from the dippers into earthenware pipes with openings at intervals, through which they are drawn by exhaust fans. The mixed acid, either cooled or warmed as necessary, is carried by lead pipes placed between each row of coolers, and is supplied to the dippers through earthenware cocks at intervals.

Nitration.—The water in the coolers is kept at 15 deg. C. The dippers having been placed in position in the coolers, are each filled with 127 pounds of mixed acid by measurement, from the acid taps, 4½ pounds of cotton waste are steeped in each dipper. To minimize decompositions each charge of cotton waste is added in about ten instalments. The wooden covers are only removed to allow steeping to be done, and are then at once replaced. The temperatures of nitration are: Initial temperature of mixed acid, 15 deg. C.; maximum after steeping, 25 deg. C.; temperature at end of nitration, 20 deg. C. The duration of the nitration varies according to the output required from the plant. One, two or three shifts may be worked per 24 hours, and the time of nitration may therefore be 24, 12, or 8 hours respectively.

The average composition of the mixed acid for a 12 hours' immersion is as follows: Sulphuric acid, 75.0 per cent; nitric acid, 15.75 per cent; nitrous acid, 1.30 per cent; water, 7.95 per cent. For an eight hours' immersion a higher percentage of nitric acid and less water is used; for a 24 hours' immersion less nitric and more water. The average composition of the waste acid for a 12 hours' immersion is: Sulphuric acid, 77.8 per cent; nitric acid, 11.0 per cent; nitrous acid, 1.5 per cent; water, 9.7 per cent.

Recovering the waste acid.—When the nitration is complete, the "dippers," covered with light aluminium lids, are placed on barrows, wheeled to the centrifugals, situated at the end of the "coolers," and the whole contents tilted out into the centrifugal. Four dippers are loaded into each centrifugal, and the guncotton having been uniformly spread round the basket, the centrifugal is run for six minutes, to remove waste acid. At the end of that time about 1 pound of waste acid is still adhering to each pound of guncotton. The centrifugal cover, made of light aluminium, is not fixed to the centrifugal in any way, so that as little resistance as possible may be offered when there is a decomposition. This is the usual arrangement in the case of acid centrifugals. The cone of the centrifugal projects through a circular opening in the center of the lid and is covered by a small loose aluminium box. Small holes are cut in the sides of this box, and are of service in warning the workmen when there is a decomposition, as fumes are generally seen to issue there first.

Drowning the guncotton.—When the waste acid has been removed, the guncotton is quickly lifted out of the centrifugals and thrown under the revolving paddles of the drowning tanks, which immediately immerse it. The men who do the discharging are provided with rubber gloves and wear thick flannel hoods, which completely cover the head, arms, and breast. The hoods are fitted with strong glass windows, and are connected by light rubber tubing to a supply of pure compressed air.

Prewashing.—After a given quantity of guncotton has been drowned, the water in the tanks is run off and the guncotton thrown on to draining tables forming part of the drowning tank. It is then loaded into the prewashing centrifugals, the acid water wrung out, and washed for a few minutes with cold water from a hose, to remove adhering acid. No special precautions, however, are taken to remove all acid at this stage. The bulk of the water having been removed, the guncotton is loaded from the centrifugals into bogies, and conveyed to the boiling house.

The 62 dippers in each cooler form a "charge." Eight charges are worked by each shift. The yield is 159 per cent of dry guncotton on the dry carded cotton. The output per shift consisting of 17 men is, therefore: $4.5 \times 159 \times 62 \times 8 \div 100 = 3{,}549$ pounds.

NITRATING CENTRIFUGALS.

The next attempt at simplifying the Abel process was one in which the nitration was effected in the acid centrifugal. A number of nitrating centrifugals have been patented, particularly in Germany, but the best known patterns are those of Messrs. Selwig and Lange, of Brunswick.

The latest pattern is known as the "nitrating centrifugal with acid circulation." It consists of the usual outer casing with cover, and an under-driven rotating basket perforated with a number of holes. The machine is provided with a hinged cover with communication to an exhaust fan, and there are pipes with cocks suitably arranged for running in the nitrating acid and drawing off the waste acid. The method of working is briefly as follows: The basket is rotated slowly, and the nitrating acid run into it and between it and the iron casing, up to about the rim. The cotton waste is introduced in small quantities at a time, and this may be done while the nitrating acid is running in. During nitration the basket is rotated at the rate of 20 to 30 revolutions a minute. The effect of this rotation is to cause the nitrating acid to circulate continuously through the cotton waste. On completion of the nitration the bulk of the waste acid is drawn off and the centrifugal set into rapid motion to get rid of as much more of the waste acid as possible.

According to Selwig and Lange's circular their centrifugals are now made in two sizes. The larger size nitrates 22 to 26½ pounds of cotton waste, the smaller 14½ to 17½ pounds, respectively. The yield is stated to be 160 per cent. The time of a complete nitrating operation is an hour.

Messrs. Curtis and Harvey have an installation of these centrifugals at their Dartford Works; they are of the earlier or "without acid circulation" type, and of the smaller size. Mr. MacDonald has kindly supplied me with some details in connection with their working.

The charge is 17½ pounds of cotton waste, the proportion of nitrating acid to cotton waste is 50 to 1, and its average percentage composition: nitric acid, 23.15; sulphuric acid, 69.35; water, 7.5. The nitrating operation for the production of cordite guncotton, from the running in of the nitrating acid to the removal of the guncotton, takes about an hour. The initial temperature is 15 deg. C., the final 23 deg. C. After extraction of the waste acid, the guncotton retains approximately its own weight of waste acid containing a fairly high percentage of nitric acid, which is lost in the immersing. Analyses of the waste acid made at Dartford show the following mean alteration in the composition of the nitrating acid, viz., a loss of 1.70 in nitric acid, and gain of 0.91 in sulphuric, and 0.76 in water.

DISPLACEMENT PROCESS.

Guncotton has been made at Waltham Abbey by the displacement process since August, 1905. The installation consists of a number of units of four pans worked together. The pans are of earthenware and circular, 3 feet 6 inches in diameter, and 10 inches deep at the side of the pan; the bottom has a fall of 2 inches to the outlet, which is three-quarters of an inch in diameter; they are supported on earthenware pedestals about 1 foot 10 inches above the floor level. The four pans are connected together by lead pipes, and these are again connected to the nitrating acid supply pipe, to the strong and weak waste acid pipes, and to a waste water pipe, through a gage-box, where the rate of flow is determined while the waste acids are being run off. Gravities of the acids are also taken in this box. The process proceeds as follows:

A small perforated plate is placed over the outlet of each pan, and four perforated segment plates making a complete disk about one inch less than the inside diameter of the pan, are placed on the bottom. Aluminium fume hoods, which are connected to an exhaust fan, having been placed on the four pans, the stoneware cock on the acid supply pipe is opened, and the acid allowed to rise in the pans to the proper level. The nitrating acid is cooled in summer and warmed in winter, so as to maintain the same temperature of final nitration all the year round. The composition of the nitrating acid is 70½ per cent sulphuric acid, 21 per cent nitric acid, 0.6 per cent nitrous acid, and 7.9 per cent water; the quantity in each pan above the bottom plates is 600 pounds; and below the plates is an additional 50 pounds. A charge of 20 pounds of cotton waste is then immersed in the acid, handful by handful, aluminium dipping-forks being used for the purpose. When all the cotton waste has been pushed under the surface of the acid, perforated plates in segments are placed on the top of it, care being taken that all cotton waste is below the surface of the acid, and a film of water at a temperature from 5 deg. to 8 deg. C. is run very gradually on the surface of the plates through a distributor. The film of water prevents the escape of acid fumes and the fume hoods are then removed. The time required for dipping a charge is a quarter of an hour.

The nitration is allowed to proceed for 2½ hours. At the expiration of this period the cock leading to the gage-box is opened, and the waste acid allowed to run off at the rate of about 17 pounds a minute. Water, cooled, if necessary, is run on the top of the perforated plates, through the distributor, at an equivalent rate. The major portion, amounting to about 80 per cent of the total waste acid, is returned to the acid store tanks to be revivified with Nordhausen sulphuric and new nitric acids. The composition of this waste acid is 72.70 per cent sulphuric acid, 17.30 per cent nitric acid, 0.65 per cent nitrous acid, and 9.35 per cent water. The remaining 20 per cent of the waste acid is sent to the acid concentration factory for denitration and concentration. The quantity of acid thus dealt with amounts to about 4 pounds for every pound of guncotton. Its composition is 61.0 per cent sulphuric acid, 17.35 per cent nitric acid, 0.55 per cent nitrous acid, and 21.10 per cent water. A small proportion of the water which follows the recoverable waste acid is slightly acid to the extent of 0.1 pound for every pound of guncotton made. This is the total quantity of acid that is lost during the process. In the direct dipping and nitrating centrifugal processes the quantity of waste acid left in the guncotton is at least equal to the weight of the guncotton.

The whole of the acid is displaced in three hours, and the water, which should fill the pan, is run through the guncotton, the guncotton drained down and sent over to be boiled. These operations occupy about an hour.

The following table gives the principal figures in connection with the four nitration processes described:

Process.	Nature of Dipping Vessel.	Acids.					Cotton Waste Used, Pounds.	Acid Used per Pound of Cotton Waste, Pounds.	Time of Nitration, Hours.	Yield on Dry Cotton Waste, Per Cent.	Output per Man per Week, Pounds.
		Analysis, Per Cent.				Quantity, Pounds.					
		Sulphuric Acid.	Nitric Acid.	Nitrous Acid.	Water.						
Abel	Cast-iron pan and earthenware pot	74.00	18.00	0.60	7.40	13.75	1¼	11.0	12	163.75	458
Ardeer: Direct dipping	Cast-iron pot	75.00	15.75	1.30	7.95	127	4½	28.2	12	159.40	1112*
Dartford: Nitrating Centrifugal	Centrifugal machine	69.35	23.15	....	7.50	800—1100	16—24	50.0	1	160.00	....
Waltham Abbey: Displacement	Earthenware pan	70.50	21.00	0.60	7.90	650	20	32.5	2½	170	1742

The following are the principal advantages which the displacement process possesses over the Abel process, and over the direct dipping and nitrating centrifugal processes where they are similar to the Abel process.

1. The displacement process takes the place of the

* Read before the Society of Chemical Industry.

processes of dipping, squeezing out excess acid, digesting in pots, acid centrifugaling, immersing, and water centrifugaling.

2. The actual dipping of the cotton waste is a very much less laborious operation—the heavy labor of squeezing out the excess acid is done away with, the absence of fumes makes the work much healthier, and injuries to workmen from acid splashes are almost unknown.

3. Loss of guncotton due to decomposition in the digesting pots and acid centrifugals, and consequent inconvenience and danger to workmen from nitrous fumes, are done away with, and the heavy loss from breakages of pots and lids is saved. Three and a half years' experience has proved that the earthenware pans are very lasting.

4. Fumes during dipping, loading, and unloading acid centrifugals and immersing, are avoided.

5. The quantity of acid lost is very much reduced. This reduction means also very much less pollution of the escaping washing water.

6. The recovered waste acid is very much cleaner, a matter of the greatest importance from the point of view of revivification and concentration.

7. The mechanical loss of guncotton in the acid and water centrifugaling processes, and in the immersing process, is saved.

8. A more through preliminary washing of the guncotton is obtained with an expenditure of about one-fifth of the quantity of the water, and less boiling, with consequent consumption of steam, is required in order to reach a given standard of purity.

9. Great saving in power is gained by the abolition of the acid and water centrifugals, and in the reduction in the quantity of water which has to be pumped.

10. Renewals of plant, and repairs to plant and buildings are exceedingly low.

11. The number of hands employed for any given output is much less—the total cost of labor being reduced by two-thirds.

12. The yield is improved; it averages 170 per cent.

13. Finally, a more stable guncotton, of more uniform composition, is produced. It is also far cleaner, and contains notably less mineral matter.

STABILIZATION.

Boiling.—Originally stabilization was effected by prolonged washing in cold running water followed by a very short treatment with a boiling alkaline solution. Boiling, as now understood, did not form part of the process of guncotton manufacture when manufacture was started at Waltham Abbey early in 1872. About the middle of 1873, however, boiling vats were put up at Waltham Abbey, but no records exist, unfortunately, about the details of the early boiling processes. In the official "Notes on Gunpowder and Guncotton," published by the War Office in 1878, it is stated that guncotton manufactured at Waltham Abbey underwent two boilings by steam in wooden vats for 8 hours each, the water being extracted after each boiling by wringing for 3 minutes in clean water centrifugal machines. The same boiling process was in use in 1888, according to a later edition of the same book. Five years later each boiling was extended to 12 hours, and the boiling lasted for 5 days and nights—that is, the guncotton received 10 boilings of 12 hours each. In April, 1894, this system of boiling was replaced by a system characterized by short boilings at the commencement of the process, the time of successive boilings being gradually increased. The scheme of boiling was as follows:

No. of Boiling.	Duration in Hours.	No. of Boiling.	Duration in Hours.
1	2	7	6
2	2	8	6
3	4	9	9
4	4	10	9
5	6	11	12
6	6	12	12

This system of boiling was continued with but slight modifications until August, 1905. On the introduction of the displacement dipping process it was found, as already stated, that guncotton made in this way was brought to a condition of stability by the boiling process then in use, and just referred to, at an earlier stage than guncotton made by the Abel process. A probable explanation of this fact is that during the displacement process a zone of acid liquid at a comparatively high temperature—somewhere about 40 deg. C.—passes through the whole of the guncotton in the dipping pan. The action of this hot acid liquid may be to oxidize certain organic impurities which are certainly present, and to cause the breaking down of unstable nitrogen compounds into soluble or non-reactive bodies. Systematic experiments were therefore carried out in 1905, to determine the most suitable and most economical method of purification by boiling, for displacement process guncotton. In the principal experiments two types of boiling were employed—one in which long boilings were used at first, followed by short boilings; the other in which short boilings were used at first, followed by long boilings. The following deductions were made from the results obtained in these experiments:

1. Purification of guncotton obtained by means of long boilings at the beginning followed by shorter boilings later, is superior to that obtained when the reverse condition holds. This is substantiated by the following considerations: Examination of the waters showed that neutrality is obtained earlier; that less decomposition of the guncotton takes place; that the stability, as shown by the various stability tests, is greater; and that a stable condition is attained earlier.

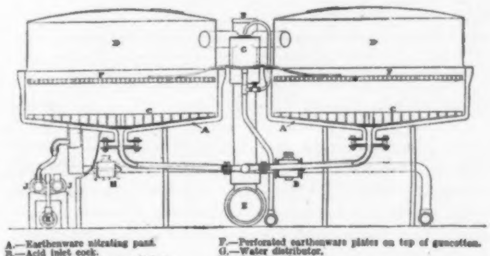
2. A displacement washing after a long acid boiling at an early stage is a beneficial treatment. This treatment is probably responsible for the early attainment of neutrality.

The system of boiling determined on as a result of these experiments was as follows:

No. of Boiling.	Duration in Hours.	No. of Boiling.	Duration in Hours.
1	12	6	4
2	12	7	4
3	4	8	2
4	4	9	2
5	4	10	2

With a cold water displacement wash after the first two boilings. A full account of these investigations was given in a paper on the purification and stabilization of guncotton, read by Dr. Robertson before this Section on June 16th, 1906. This system of boiling is still in use at the Royal Gunpowder Factory.

The question of how the purification of guncotton can best be effected cannot, however, be considered as settled, nor can the system which has just been described, although it undoubtedly gives an excellent guncotton at the Royal Gunpowder Factory, be applied to guncotton made by other processes, at other factories, without full investigations as to its suitability. Another matter which must be taken into account in connection with the purification of guncotton by boiling, is the nature of the water available. The water at Waltham Abbey is very hard, and its alkalinity may



A.—Earthenware nitrating pans.
B.—Acid inlet cock.
C.—Perforated earthenware plates.
D.—Aluminium fume hoods.
E.—Fume pipe.
F.—Perforated earthenware plates on top of guncotton.
G.—Water distributor.
H.—Outlet cock.
J.—Waste acid pipes.
K.—Waste water pipe.

WALTHAM ABBEY GUNCOTTON DISPLACEMENT PLANT.

be an important factor in the success of the boiling treatment in use there. This question is perhaps connected with another one, and that is, that the boiling of guncotton can be carried too far. The effect of boiling, while it no doubt breaks down impurities, also no doubt breaks down the stable ester itself. It is well known that if guncotton is boiled for a sufficiently prolonged period, the percentage of soluble matter will rise and the nitrogen-content will fall. The breaking down of the ester will be accompanied by the formation of acid bodies, and the presence of alkali in the water will neutralize them and prevent them from reacting on the guncotton.

I have been obliged, owing to want of time, to treat this question of purification very briefly, but it is undoubtedly the most important one in connection with the manufacture of guncotton. One or two matters have been touched upon, in connection with which further work is necessary, but there are many others which will repay very careful investigation and research.

PULPING.

On completion of the boiling process the guncotton is transferred to a beating engine somewhat similar to that employed for pulping the raw material used in the manufacture of paper. It consists essentially of a large iron roller armed with steel knives, and a bedplate also provided with knives. The roller revolves, and as the guncotton passes between the two sets of knives, it is reduced to pulp of any desired fineness. As the pulping process proceeds, the roller is gradually lowered nearer to the bed-plate.

Since the introduction of a thorough system of purification by boiling, Abel's original idea that the pulping and washing the guncotton received in the pulping process had a very material effect on its purification, no longer holds good to the same extent. At the same time there is no doubt that the very long staple guncotton before pulping retains in its tubes unstable bodies which no reasonable amount of boiling will remove. The effect of pulping is to materially reduce the length of the fibers and, at the same time, to produce a certain amount of crushing in them. This allows of impurities of an acid character in the tubes being removed, either mechanically or by diffusion.

REMOVAL OF FOREIGN BODIES.

After pulping, it is now customary to treat the guncotton in some mechanical way, in order to remove from it particles of metal, grit, and foreign bodies of a similar character. At the Royal Gunpowder Factory this is effected by running the guncotton pulp, suspended in a large volume of water, through grit traps, placed at intervals in a long shallow trough, the bottom of which is covered with a blanket. The foreign bodies, being almost entirely heavier than the guncotton pulp, are retained in the grit traps, and the fine sand, also present in some quantity, is caught by the woolly blanket. An electromagnet in the last grit trap removes any magnetic particles passing the ordinary grit traps. It is surprising what a large quantity of foreign bodies are removed by these arrangements. In addition to grit traps and troughs, some factories use what is known as a knotter, the function of which is to remove small knots and any large pieces of guncotton which may have escaped complete pulping.

POACHING.

Washing the guncotton during the pulping is effected in some factories by the use of drum washers fixed to the beating engine; in other factories and at the Royal Gunpowder Factory this washing is done in separate vessels, termed "poachers." The poachers in use at Waltham Abbey hold about 10 hundredweight of guncotton and 1,100 gallons of water, and are fitted with power-driven paddles for agitation purposes. The guncotton receives at least three washings; it is allowed to settle down after each washing, and the washing water is removed by a skimmer. The washing water contains in suspension foreign bodies of a lower specific gravity than guncotton, and in the case of the earlier washing waters, there is always present a scum containing nitro-bodies of low stability.

BLENDING.

A further purpose served by poaching is the thorough blending of a number of different batches. This is a final blending, but at the Royal Gunpowder Factory there exists a regular system of blending right through the whole of the manufacturing process. This system is briefly as follows: The cotton waste reaches the factory in consignments from different contractors. The waste is drawn from store in proportion to the quantities on the contracts, and is mixed and passed through the teasing machine in these proportions.

The next process where blending is possible is in charging the boiling vats. Two vats are filled simultaneously from a number of sets of pans—two pans of each set of four going into one vat; the other two of the set into the other vat. On completion of the boiling, four vats are emptied simultaneously into 32 beaters. This insures the guncotton from the four vats being blended together in the beating process.

On completion of the pulping, the beaters are run alternately into the poachers in such a manner that the contents of the 32 beaters are blended into eight poachers. The guncotton in the eight poachers is therefore uniform throughout.

The system produces guncotton of very uniform nitrogen-content. In the year 1907-8, 291 tests, representing 600 tons of guncotton, gave the following nitrogen result:

Maximum.	Minimum.	Mean.
Per Cent.	Per Cent.	Per Cent.
13.05	12.98	13.0195

MOLDING.

For convenience in drying the pulped guncotton it is molded by light hydraulic pressure into cylinders which measure about 5½ inches in height and 3 inches in diameter. This is effected by running the guncotton pulp into a molding machine provided with a number of holes into each of which fits a hollow plunger. These plungers are connected with a vacuum engine, and a good deal of the water is sucked out of the pulp by their means. The mold block containing the guncotton is transferred to a hydraulic press, and pressure is applied, which has the effect of removing more water and of squeezing the pulp into a condition of sufficient consistency to allow of its being handled with care. In this lightly compressed form a very much larger quantity of guncotton can be dealt with in a drying chamber of any given dimensions than if it is dried in the condition of ordinary pulp, and in its compressed form it possesses the further advantage of being able to be dried on fixed racks. This does away with the necessity and risk of moving drying trays or similar arrangements in a stove. It is also obvious that much less dust is produced.

PRESSING.

If intended for use in torpedoes, mines, or other

demolition work, the guncotton is molded into suitable shapes, as described above, and the molds are then subjected to powerful hydraulic pressure, amounting to about 6 tons on the inch, to produce the finished slabs or primers.

CONCLUSION.

I have endeavored, very imperfectly I am afraid, to give in a comparatively brief time some account of the history of the manufacturing processes involved in the production of guncotton. Other nitrocelluloses, for the manufacture of which some of the processes are slightly modified, have not been touched upon. The subject is a very wide one, and if it were attempted to go into details, each process would require more time devoted to it than has been given to the whole manufacture.

This paper has consisted almost entirely of manufacturing details; very little attempt has been made to deal with the chemical questions involved, and nothing at all has been said about the chemistry of the nitration of cellulose nor of the chemistry of the nitrocellulose molecule. The published information on both these subjects is very considerable, and is constantly increasing. I had originally intended to attempt a brief summary of the more important papers, but I had to abandon it as quite impracticable. What must, however, strike any manufacturer of nitrocellulose when he consults the literature of the subject, is that the great bulk of it, although of intense interest, is either too theoretical for practical application, or else that the data, being for the most part the result of laboratory experiments, are not always a sure guide as to what will happen on a manufacturing scale. Our experience at the Royal Gunpowder Factory is, and it is also no doubt the experience of other manufacturers, that all experimental work should be based on sound chemical principles, but to be of practical use it must be conducted on a manufacturing scale wherever possible, and that laboratory work comes in when it is required to ascertain the nature of the results obtained. I venture to think that this is true in the case of several chemical manufactures, and it is most undoubtedly true in the manufacture of guncotton, and I therefore offer the suggestion to any of those chemists who wish to further improvements in the production of guncotton, to take the manufacturer into their confidence, work with him, and to get him to work with them.

TIDAL POWER.*

SOME OLD AND NEW TIDAL MOTORS.

BY W. C. HORSNAILL, A.M.I.MECH.E., A.M.I.E.E.

ALMOST everyone interested in the application of power must have wondered, at some time or another, why more advantage is not taken of the ebbing and flowing of the tides around our coasts. The rise and fall of the enormous volume of water surrounding the British Isles would develop enough power to supply the whole kingdom, if only this tidal action could be fully utilized. Unfortunately, however, certain natural conditions are necessary before we can harness any portion of this waste energy. A reservoir or pound is required to produce a flow of water, and if the cost of constructing the works is to be kept within reasonable limits, the pound can only be formed by building a dam across a natural creek or estuary. These requirements are met with on the shores of many of our estuaries, and to some extent they have been taken advantage of by the erection of tide mills. Old charters show that tidal power was used for grinding corn as early as the eleventh century, and tide mills have been in operation for the same purpose from that time to the present day.

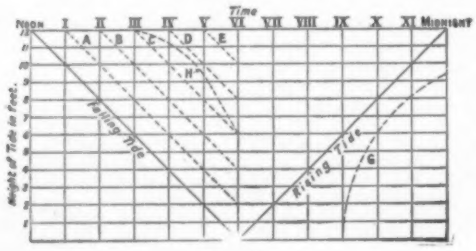


FIG. 1.

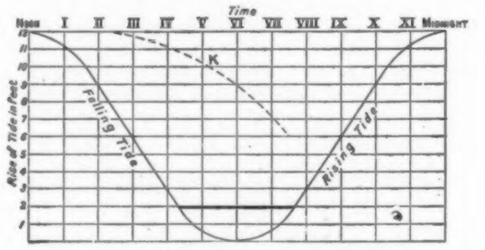


FIG. 3.

No records exist showing how the earliest tide wheels were arranged, but particulars are available of several mills which were erected in the eighteenth and nineteenth centuries. In the earlier historic mills no attempts were made to produce a fall, the power being obtained from the flow of the water into and out of the pound. To develop power in this way a wheel, similar to the paddlewheels of steamships, was used, but with a reversed action; that is to say, the flow of water drove the wheel. This arrangement entailed the raising and lowering of the wheel to suit the rise and fall of the tide, as only the bottom floats could be immersed if the best results were to be obtained.

A corn mill at one time existed at East Greenwich

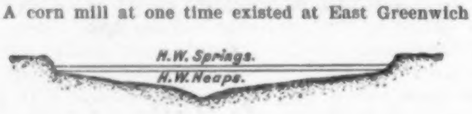


FIG. 2.

which was driven by tidal power in the way we have described. The pound had an area of about 4 acres, and the wheel measured 11 feet in diameter by 26 feet long. The power was transmitted by a bevel gear at either end of the water-wheel shaft, the pinions being free to slide up and down two square vertical spindles. The water-wheel and bevel gears were mounted upon a frame which was caused to rise and fall to suit the tides, and the power was transmitted by either bevel wheel according to which way the water-wheel was running, the other bevel pinion being thrown out of gear. By these means the machinery in the mill was always driven in one direction, in spite of the reversal of the water-wheel at each turn of the tide.

The movable frame, with the water-wheel and gear, weighed some 20 tons, and the bottom of it was extended to form a kind of shutter, which filled up the opening underneath the wheel race, all the water flowing into or out of the pound being thus compelled to pass through the wheel.

Another type of wheel was devised to overcome the drawback of having to move up and down with the tide. This wheel was fitted with hinged floats, which arranged themselves across the stream at the bottom of the periphery, while they traveled through the water edgeways during the remainder of each revolution. With floats of this type the wheel was fixed, and the tide gradually rose over it until in some cases complete immersion took place.

An arrangement of the sluices was also adopted to compel the water to pass through the wheel in the same direction, whether flowing in or out of the pound, thus doing away with the need for reversing gear between the water-wheel and the machinery to be driven.

These wheels must have been very inefficient, as the loss of power caused by the drag of the upper portion when covered was serious, and the design was soon discarded.

Following these earlier mills came the more recent examples, many of which are still in existence, while a few of them may be seen in operation. The older mills aimed at using the current of water caused by tidal action, and advantage was taken of the flow in either direction. The more modern tide wheel is arranged to operate with a considerable fall, and only develops power when the water is flowing out of the pound.

The undershot wheel with straight radial floats is usually adopted, and the mill is started at half ebb or a little later, work being continued for about five hours, or until the water rises under the wheel and chokes the tail race. These arrangements give only five hours of working during each tide, and one naturally asks why the flow into the pound cannot be used as well as the fall outward.

The principles governing the reply to this question will be more easily understood with the aid of the diagrams shown in Fig. 1. The tidal action represented begins at noon, and the period of ebb is taken at six hours; also we have assumed a regular fall for the sake of simplicity. An imaginary pound, 12 feet deep, and having straight sides, will be considered, its capacity being 600 pounds of water, or 100 pounds for every 2 feet.

If the water be run out of the pound at such a rate as will maintain a constant difference of level between the inside and the tide level outside, the fall in the pound may be represented by lines parallel to the tide line. Obviously the water may be run out of the pound under heads varying from nothing to 12 feet, and during periods of six hours to no time at all; it is therefore necessary to consider which head and corresponding time will give the best effect.

The lines *A*, *B*, *C*, *D*, and *E*, are drawn in for the purpose of settling this point, and they represent the following results:

$A = 100$ pounds an hour at 2 feet head, and for five hours $= 1{,}000$ foot-pounds.

$B = 100$ pounds an hour at 4 feet head, and for four hours $= 1{,}600$ foot-pounds.

$C = 100$ pounds an hour at 6 feet head, and for three hours $= 1{,}800$ foot-pounds.

$D = 100$ pounds an hour at 8 feet head, and for two hours $= 1{,}600$ foot-pounds.

$E = 100$ pounds an hour at 10 feet head, and for one hour $= 1{,}000$ foot-pounds.

From these figures it will at once be seen that 6 feet of head, or half the total fall, gives the greatest amount of energy.

The next point to decide is whether power can also be obtained from the water running into the pound.

If we attempt to use the inward flow after the tide has risen 6 feet the level will be represented by the line *G*, and the power will be doubled, but arrangements would be necessary whereby the water remaining in the pound at 6 P. M. could be run out instantly and allow of immediate filling at midnight. In actual practice these requirements would entail enormous sluices to enable the pound to be emptied and filled quickly enough, and either two water-wheels must be used or provision would be necessary to make the water pass the wheel always in the same direction.

Then, again, it must be remembered that our diagram assumes an ideal pound with straight sides and flat bottom, the latter being level with or below low-water mark. The pound to be met with in existing practice is of the section shown in Fig. 2, and the bottom of it, together with the outlet, is usually considerably above the lowest level of the water outside.

When running the water off, this feature offers no difficulty, as during the early part of the working period the level falls more slowly than the tide outside,

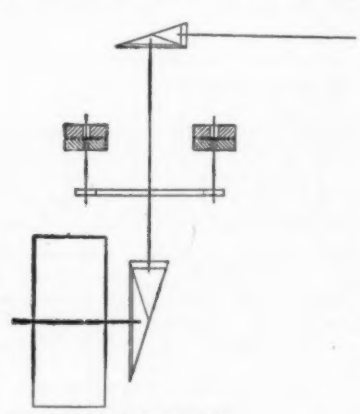


FIG. 4.—MILL GEARING.

and the head increases, the conditions being shown by the line *H*. If we attempt to reverse the process, as represented by line *G*, the first 2 feet or 3 feet at the bottom of the pound would fill up very quickly and reduce the head, hence very little power could be developed. Also with a given fall the power depends entirely upon the volume of water, and as the lower half of a pound, having the section shown in Fig. 2, would only contain about 10 per cent of the total capacity very little advantage would follow any attempt to use the water running into it.

It may be urged that the above drawback could be

* The Engineer, London.

overcome by deepening the pound and straightening the sides, but the cost of such work would be enormous and out of all proportion to the gain in power.

In actual practice it is found more convenient to work for a longer period than three hours, even at some sacrifice of efficiency, and the level of the pound would be approximately represented by the curve *K* in Fig. 3, which shows the head reduced to 4 feet, while the hours of running have been extended from three to five. This latter feature varies according to whether the tides are springs or neaps. During spring tides the level in the pound will rise to a depth of several feet over the mud flats, whereas at neaps the latter may only be covered by a few inches. Then, again, the period of work may be reduced or extended according to the amount of power required; thus high powers for short periods can be substituted for low powers during longer intervals.

It will be noted that in Fig. 3 the rise and fall of the tide is shown by a curved line which represents the true action of the tides when unaffected by strong winds. This feature tends to increase the fall, and is of considerable advantage when the extra power can be utilized in the manner to be described later.

Before passing on to the possibilities of tidal power in the future it will be interesting to consider the arrangements obtaining in such tide mills as are still in operation or have only recently been shut down.

Fig. 6 shows a mill at Woodbridge which is regularly worked for grinding corn.

The pound covers an area of 310,000 square feet, but is very shallow, excepting for a narrow channel in the middle. The average rise and fall of the tide is about 12 feet, and the wheel works with a 6-foot fall, operations being begun a little before half ebb and continued for 5½ hours at spring tides. The wheel is of the undershot type, measuring about 14 feet in diameter by 6 feet in width, and it is provided with radial wooden floats. On the wheel shaft is fitted a bevel pit-wheel which gears into a pinion on a vertical shaft. Just above this pinion a large spur wheel is fixed, which drives the pinions of four pairs of millstones arranged at equal distances. This wheel and gearing are shown diagrammatically in Fig. 4.

The vertical shaft is continued up through the mill and drives a horizontal shaft, through bevel gear, from which all the remaining tackle is driven. The water-wheel runs at about six revolutions, while the speed of the millstones is 130 revolutions per minute, 10 to 12 horse-power being developed when two pairs of stones are being driven together with the other machinery.

Fig. 5 is a view of the well-known tide mill at Walton-on-the-Naze. Occasional grinding has been carried out at this mill within the last two years, and it was regularly at work within ten years of the present time.

The pound covers an area of about 1,110,000 square feet, the power being obtained from one water-wheel of the old-fashioned undershot type, with straight radial floats.

Another tide mill situated at St. Osyth (near Clacton-on-Sea) is illustrated in Fig. 7.

This pound has an area of about 1,120,000 square feet, and the power is absorbed by two water-wheels 18 feet in diameter by 6 feet wide, each capable of developing 20 horse-power. Seven pairs of stones are driven through the usual gearing, and the two periods of running total up to nearly twelve hours out of the twenty-four at spring tides. This mill is still regularly worked with apparently profitable results.

The waste of power in these instances must be very marked, as an undershot wheel with straight floats will only give an efficiency of about 30 per cent, and the losses in the gearing are very heavy. There is little doubt but that the power available at the machines could be trebled by installing turbines and the most modern forms of transmission gear. With a turbine the efficiency would be increased to at least 80 per cent, and the millstones could be driven direct from the turbine shaft by ropes, while the main horizontal shaft could be operated by a half-twist rope or belt. Thus, with an old-fashioned undershot wheel and a pound of sufficient area to give 100 horse-power, only 30 horse-power would be available at the wheel shaft, or, allowing 20 per cent less in the gearing, 24 horse-power for actually driving the millstones and other tackle. This figure would be increased to 75 horse-power if a turbine were used in conjunction with direct rope driving, and the initial outlay would certainly be no greater than for an undershot wheel—if, indeed, it were not considerably less.

The following conditions have hitherto been considered necessary if a tide mill is to be laid down with any prospect of success:

1. The pound must naturally exist in the form of a tidal estuary or creek which will only require a short dam to close the opening toward the sea.

2. The proposed pound must not be in use for purposes of navigation.

3. A rise and fall of the tide of at least 12 feet is essential.

4. The mill must be situated near to an existing road, for the cost of constructing a private road would be prohibitive.

5. A local market must exist for the products.

The number of situations which meet these requirements is exceedingly limited, and the most favorable positions are already occupied. A low-lying shore with moderate range of tide, such as may be met with along the Essex coast, appears to offer the necessary conditions more often than they are found where the shores are higher. Then again, in the Bristol Channel and the estuary of the Severn, where the tide

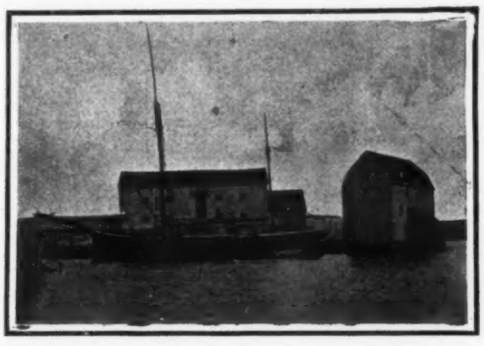


FIG. 6.—TIDAL CORN-GRINDING MILL AT WOODBRIDGE.

range is the largest in the country, the natural features do not permit of the use of tidal power without costly works for controlling the flow.

Tide mills have been exclusively used hitherto for the grinding of corn, and although flour was at one time produced, their operations have been mainly confined, in recent years, to the grinding of oats, barley, etc., for the neighboring farmers.

The development of the water turbine, together with the electrical transmission of power and the practicability of storing the latter, have considerably altered the economical aspect of this subject; but it will be demonstrated below that the reduction in the cost of other sources of power has more than kept pace with these developments and tidal power cannot now successfully compete with gas or steam.

We will first consider the cost of providing electric current for a constant supply by means of tide-driven generators in conjunction with a storage battery.

The best way of attacking this problem will be to work out the cost of production at one of the tide mills described. For this purpose the mill at Walton-on-the-Naze offers the advantage of a market for lighting in the immediate vicinity; moreover, the undertaking has now nearly ceased to exercise its original vocation of grinding.

The area of the pound measures 1,110,000 square feet, and although the rise and fall at the tail race is not the full 12 feet, it may be taken at this figure, as the cutting off of the last 2 feet of fall has no effect. This will be understood on reference to Fig. 3, the lowest level at the back of the mill being represented by the black line.

In view of the cross section of the pound an average depth of 3 feet will represent the largest volume of water available for producing power at neap tides. As regards the fall, Fig. 3 shows us that the head varies between 4 feet and 8 feet, the average being 6½ feet, but allowing for neap tides, we must not reckon on more than 5 feet fall for a period of five hours.

FIG. 5.—TIDAL MILL AT WALTON-ON-THE-NAZE.

These figures give us 108 horse-power, which would be reduced to 85 horse-power by losses in the turbine. Naturally, more power could be developed at spring tides, but we have to allow for the worst conditions.

This 85 horse-power for five hours has to be distributed over the full tidal period, which, for the sake of simplicity, may be taken at twelve hours, and the battery must be capable of storing a proportion of the output, dependent upon the load factor. At first sight a storage of two-thirds of the power might appear sufficient, but allowance has to be made for the moving forward of the tidal periods from day to day. In December, with a purely lighting load and high water at, say, 4 P. M., a considerable proportion of the power might be used while current was being generated; on the other hand, when work began at 11 A. M. almost the entire load for the tidal period would come upon the battery. If the demand for power were large the conditions would be more favorable as regards storage, but this advantage would be balanced by the lower price obtainable. Moreover, with the large storage capacity needed to carry out our scheme the "peaked" loads involved by a lighting supply have little effect, and it is doubtful whether any demand for power exists near the mill. Further, if the tidal power is successful for a purely lighting load, the results could only be improved by the inclusion of motors, hence lighting only will be considered.

For various reasons it is better to install two turbines of 42½ horse-power in place of a single wheel capable of dealing with the entire flow. The speed with the low fall available will only be about 75 revolutions per minute, hence gearing must be resorted to for the first reduction followed by a belt or ropes to the dynamo. Allowing for a loss of 10 per cent in the gear and 8 per cent in the generator 52 kilowatts will be developed for charging the battery.

To guard against any possible chance of breakdown two dynamos should be allowed for of, say, 30 kilowatts each, with such gearing arrangements as will permit of running either machine from each turbine separately or from both at once.

In view of the employment of metallic filament lamps and the nearness of the town, the center of which is only 1,500 feet distant from the mill, we shall be fully justified in adopting a voltage of only 100, the cost of the battery being thereby greatly reduced. Even with this low pressure fifty-five cells are required, and they must be capable of being charged at the full output of the dynamo, or at a rate of nearly 500 amperes.

A continuance of the charge for more than five hours cannot be depended upon, as tides are very uncertain in their behavior, and with a strong wind from the northwest the rise would be greatly lessened. It will, however, be advantageous to have a battery of ample capacity, say 2,500 ampere-hours, out of which 2,000 ampere-hours will be forthcoming under the most unfavorable conditions as regards power for charging. To complete the equipment a suitable switchboard and connecting cables will be necessary, the existing mill being capable of housing the whole apparatus without much alteration.

The above particulars will enable a comparison to be made, as regards cost, with the same results derived from a generating plant operated by a gas engine and producer, which represents the cheapest possible alternative method of providing the current.

As we have assumed a lighting load only, no very pronounced peak can be expected, the maximum demand being continued for two to three hours in the darkest season. In view of this feature we shall not be wrong in settling upon a dynamo having the same output as for the turbine, thus entailing a gas engine of 85 B. H. P.; but to insure the same freedom from risk of breakdown as with the turbine plant the gas engines, products, and generators must be in duplicate. The capacity of the battery need be little more than sufficient to carry the heaviest load for a few hours with the assistance of one engine and dynamo, as the latter could be kept running long enough partly to recharge the battery for the night load if one plant were under repair. In the ordinary course the heavy winter evening loads would be carried by both plants, the battery being held in reserve for the night.

FIG. 7.—TIDAL MILL AT ST. OSYTH.

The heaviest loads would occur on Saturday nights, when many of the shops remain open until 10 or 11 P. M., giving a period of about six hours at the darkest time of the year. The turbine battery is capable of giving out 2,000 ampere-hours, and has to take charge of the load for seven hours without assistance from the dynamos. Half this capacity or 1,000 ampere-hours should be ample allowance for the gas-driven plant.

The chief remaining charge against the running of the water or gas plant is attendance. One man would be sufficient for the gas installation under any circumstances, and, although a certain amount of over-

time would be entailed during the darkest period of the year, we may set these extra hours against the greatly reduced attention required in the summer, an allowance being made for full time throughout the year.

The conditions under which the turbines would be worked in the winter time are more severe, but it is simply a question of being "on watch" with little to do, and during the summer months one short spell of charging a day would keep up the supply. It is probable, therefore, that one man would be willing to undertake the work. Then again, assuming the attendant to be responsible for keeping the plant in order, the extra work entailed by the gas engines would balance the longer hours pertaining to the running of the turbines, and we may assume the cost of attendance to be the same in either case.

Repairs and depreciation would be much heavier for the gas plant than for the turbines, and allowance has been made for this feature in the cost figures below.

The rent of the mill has been assumed at $500 per annum, while ground rent is allowed for in the gas installation.

We now have all the particulars to enable a comparison to be made between the cost of producing current by tidal power and gas plant respectively, but to arrive at the running costs the capital expenditure must be set out, the figures being approximately as follows:*

Tidal Power.

Two turbines, with bevel gear, etc.	$3,000
Two dynamos	1,000
Switchboard	500
Battery	4,000
	$8,500

Gas Power.

Two gas engines and producers	$4,500
Two dynamos	1,000
Switchboard	500
Battery	2,250
Buildings	1,000
	$9,250

Note.—Foundations and erection are included.

These figures enable us to introduce the correct capital charges into the running costs, which will come out approximately as given below:

Tidal Power.

Attendance	$400
Stores	25
Battery upkeep and depreciation at 10 per cent	400
Depreciation and repairs on other plant at 7 per cent	315
Interest at 5 per cent	425
Rent	500
	$2,065

For the purpose of comparing the running cost of the gas installation we must decide upon a definite number of units per annum. The hours of darkness between half an hour after sunset and 11:30 total up to about 1,800, and the turbine plant would certainly carry an average load of 200 amperes for each seven hours between tides, thus giving out 20 kilowatts an hour, or 36,000 B. T. U. during the year. Some allowance must also be made for a few lights during the night and early morning, also in cellars and other dark places in the daytime, hence we may reasonably increase the annual load to 40,000 B. T. U.

Allowing for losses of 10 per cent in the battery, and 5 per cent in the belt drive, and 7 per cent in the generators, this figure represents about 67,000 horse-power hours, which may be produced from, say 75,000 pounds of anthracite, in view of the fact that the gas engines will always be run fully loaded. 75,000 pounds = 33½ tons, costing a total of $250.

Gas Power.

Attendance	$400
Stores	75
Battery upkeep and depreciation at 10 per cent	225
Repairs and depreciation on other plant at 10 per cent	700
Interest at 5 per cent	460
Ground rent	125
Fuel	250
Water	25
	$2,260

These comparative figures show us that under certain conditions tidal power for the production of electric current can be commercially successful, at any rate so far as the cost of generation is concerned. When distribution is included, it will be found that unless a market exists in close proximity to the power, the tides could not be used for a constant supply, as the cost of transmission to any considerable distance would more than counterbalance the saving of fuel for gas power.

For industries such as corn grinding and flour milling, which can be carried on where the power is developed, tide mills should prove successful, especially in view of the almost trebled output which may be expected from the modern turbine. Also for pumping, power could be profitably transmitted over a considerable distance, as the storage reservoir would do away with the need for the battery, which accounts for the largest item in the running costs.

Beyond these purposes it is difficult to see how tidal power, as at present used, can possibly prove successful in competition with gas. The suggestion is sometimes made that large areas of water such as Langston Harbor might be inclosed and the tidal power utilized, presumably for electrical distribution. There is no denying that a large amount of power would be available, and with a fairly steady demand extending over ten hours a day, tide wheels might prove successful.

For large powers a battery would be prohibitive, on account of the enormous capacity required, hence the alternative standby gas engine must be resorted to.

Before considering larger powers for ten hours a day with auxiliary gas engines, we will apply these conditions to the example worked out above in connection with a purely lighting load. Whether a power installation of this nature will prove successful, depends upon the relation between the fuel saved by tide wheels and the capital charges entailed by their use.

Assuming the working day to last eleven hours (6 A. M. to 5 P. M.), and the periods when no tidal power is available to extend for seven hours, we shall never have less than four hours or more than five hours a day, when the gas engines can be shut down. It must be remembered, however, that five hours' running was taken as the neap tide condition. This spell would certainly be increased to six hours at spring tides, also at each end of the curve *K*, Fig. 3, the turbines would assist the gas engines for half an hour to some extent. On the other hand, meal times have to be considered in some industries, and these intervals for breakfast and dinner would tend to diminish the available tidal power, also the short day on Saturday would have a similar effect. Allowing for these factors, five hours a day of tidal power is the highest figure which can be reckoned on, or say twenty-five hours a week out of fifty-four, the year being taken at fifty weeks.

These figures give us a total of 1,250 hours when the gas engines can be shut down, and assuming an average load of 60 horse-power, 1,250 × 60 = 75,000 horsepower hours per annum will be saved. Allowing 1 pound of anthracite at $7 a ton for each horse-power hour, the value of this power works out at $250, which is insufficient to cover the interest and depreciation on the capital cost of the turbines only, a further loss being entailed by rent for the water power or capital charges on the necessary dam work.

Turning our attention to larger powers, there is little reason to hope that the conditions would be more favorable. Take, for example, the estuary of the Colne, between Wivenhoe and Colchester, an estimate for a barrage having already been obtained by the Colchester Corporation. This estuary, which would form the pound, covers an area, including small creeks, of about 3,000,000 square feet, which would provide 230 horse-power if worked out on the same basis as our previous example. Here, in addition to the tidal water, there is a considerable flow of fresh water, probably equivalent to another 50 horse-power, making a total of 280 horse-power. Assuming an average load of 210 horse-power for 1,250 hours, a saving of 262,000 horse-power hours would be effected, the value in coal as before being nearly $900. The estimated cost of the barrage alone is $25,000, which for interest only would entail a greater annual charge than the value of the coal saved.

With very large powers, such as could be developed at Langston Harbor, the tides would have to compete with bituminous gas plants in which the by-products could be recovered, also coal could be shipped into the district in the large quantities required at a very low figure, hence the saving by using tidal power would be much reduced, and it is impossible that such a scheme could be commercially successful.

In whatever way this question is approached, there appears to be no field for tidal power so long as coal remains at its present value, and we are more likely to see the closing down of the few tide mills still in operation than any extension of this form of power to other industries.

* The estimates of costs apply only to England.—ED. SUPPLEMENT.

A Franco-Swiss conference was recently held in order to consider the much-discussed question of piercing the Jura range so as to bring the French railways into Switzerland by another route and make connection with the Simplon. This is the proposed Faucille route, and it will be of great benefit to the traffic of the two countries as well as to international traffic across Switzerland. It is hoped to arrive at a solution of the question.

TRANSMISSION OF POWER BY ROPES.

E. KENYON read a paper before the South Wales Institute of Engineers on rope-driving. He states that the introduction of cotton fiber for ropes has greatly improved rope driving. The creep or slip is less than with belts and the drive is more positive. The groove action of rope pulleys counteracts centrifugal action which is potent in belt-driving, and a much higher velocity is permissible with ropes, 7,000 feet per minute being used successfully. The annexed table gives the best practice. The ratio of power is 10 h.p. for every 1,000 feet per minute. The American continuous-rope system is contrasted with the English and its defects are pointed out. The author then discusses casing of pulleys; minimum diameter of smallest pulley; proportionate durability of ropes on large and small circumferences; arc of contact; short centers; trailing span of ropes; long centers; sustaining pulleys at unequal distances; angular driving; corner driving; shafts out of alignment; grooves of various kinds; and finishes up with different kinds of material and construction of ropes. The three-strand formation is preferred. Lubrication is also noticed.

TABLE OF HORSE-POWERS WHICH GOOD THREE-STRAND COTTON DRIVING-ROPES WILL TRANSMIT (ALLOWING A GOOD MARGIN OF SAFETY), RUNNING UPON PULLEYS NOT LESS THAN THIRTY TIMES THEIR RESPECTIVE DIAMETERS.

Rope Diameters	1".	1⅛".	1¼".	1⅜".	1½".	1⅝".	1¾".	1⅞".	2".
Minimum Diam. of Smallest Pulley	2' 6".	2' 10".	3' 2".	3' 5".	3' 9".	4' 1".	4' 5".	4' 9".	5'.
Velocity in Feet per Min.									
1,000	3·3	4·1	5·1	6·1	7·4	8·6	10	11·8	13·0
1,100	3·6	4·5	5·6	6·7	8·1	9·5	11	12·6	14·3
1,200	3·9	4·9	6·1	7·3	8·9	10·3	12	13·8	15·6
1,300	4·2	5·3	6·6	8·0	9·7	11·2	13	14·9	16·9
1,400	4·6	5·7	7·1	8·6	10·4	12·0	14	16·0	18·2
1,500	4·9	6·1	7·6	9·2	11·1	12·9	15	17·2	19·6
1,600	5·2	6·6	8·1	9·8	11·9	13·8	16	18·4	20·9
1,700	5·5	7·0	8·6	10·4	12·6	14·6	17	19·5	22·2
1,800	5·8	7·4	9·1	11·0	13·4	15·5	18	20·7	23·5
1,900	6·2	7·8	9·6	11·6	14·1	16·3	19	21·8	24·8
2,000	6·5	8·2	10·1	12·2	14·9	17·2	20	22·9	26·1
2,100	6·8	8·6	10·6	12·8	15·6	18·1	21	24·1	27·4
2,200	7·1	9·0	11·1	13·4	16·3	18·9	22	25·2	28·7
2,300	7·5	9·5	11·6	14·0	17·1	19·8	23	26·4	30·0
2,400	7·8	9·9	12·1	14·7	17·8	20·7	24	27·6	31·3
2,500	8·1	10·3	12·6	15·3	18·5	21·5	25	28·7	32·6
2,600	8·4	10·7	13·1	15·9	19·3	22·4	26	29·9	33·9
2,700	8·7	11·1	13·6	16·5	20·0	23·3	27	31·0	35·2
2,800	9·1	11·5	14·1	17·1	20·8	24·1	28	32·2	36·5
2,900	9·4	11·9	14·6	17·7	21·5	25·0	29	33·3	37·8
3,000	9·7	12·3	15·1	18·3	22·3	25·8	30	34·5	39·1
3,100	10·0	12·7	15·6	18·9	23·0	26·7	31	35·6	40·4
3,200	10·4	13·2	16·2	19·6	23·8	27·6	32	36·8	41·8
3,300	10·7	13·6	16·7	20·2	24·5	28·4	33	37·9	43·1
3,400	11·0	14·0	17·2	20·8	25·3	29·3	34	39·1	44·4
3,500	11·3	14·4	17·7	21·4	26·0	30·1	35	40·2	45·7
3,600	11·7	14·8	18·2	22·0	26·7	31·0	36	41·4	47·0
3,700	12·0	15·2	18·7	22·6	27·5	31·9	37	42·5	48·3
3,800	12·3	15·6	19·2	23·2	28·2	32·7	38	43·7	49·6
3,900	12·6	16·0	19·7	23·8	29·0	33·6	39	44·8	50·9
4,000	13·0	16·4	20·2	24·5	29·7	34·5	40	46·0	52·2
4,100	13·3	16·9	20·7	25·1	30·4	35·3	41	47·1	53·5
4,200	13·6	17·3	21·2	25·7	31·2	36·2	42	48·3	54·8
4,300	13·9	17·7	21·7	26·3	31·9	37·0	43	49·4	56·1
4,400	14·3	18·1	22·2	26·9	32·7	37·9	44	50·6	57·4
4,500	14·6	18·5	22·7	27·5	33·4	38·8	45	51·7	58·7
4,600	14·9	18·9	23·2	28·1	34·2	39·6	46	52·9	60·0
4,700	15·2	19·3	23·7	28·7	34·9	40·5	47	54·0	61·3
4,800	15·6	19·8	24·2	29·4	35·7	41·4	48	55·2	62·7
4,900	15·9	20·2	24·7	30·0	36·4	42·2	49	56·3	64·0
5,000	16·2	20·6	25·3	30·6	37·1	43·1	50	57·5	65·3
5,100	16·5	21·0	25·8	31·2	37·9	43·9	51	58·6	66·6
5,200	16·9	21·4	26·3	31·8	38·6	44·8	52	59·8	67·9
5,300	17·2	21·8	26·8	32·4	39·4	45·7	53	60·9	69·2
5,400	17·5	22·2	27·3	33·0	40·1	46·5	54	62·1	70·5
5,500	17·8	22·6	27·8	33·6	40·9	47·4	55	63·2	71·8
5,600	18·2	23·1	28·3	34·3	41·6	48·2	56	64·4	73·1
5,700	18·5	23·5	28·8	34·9	42·3	49·1	57	65·5	74·4
5,800	18·8	23·9	29·3	35·5	43·1	50·0	58	66·7	75·7
5,900	19·1	24·3	29·8	36·1	43·8	50·8	59	67·8	77·0
6,000	19·5	24·7	30·3	36·7	44·6	51·7	60	69·0	78·3
6,100	19·8	25·1	30·8	37·3	45·3	52·6	61	70·1	79·6
6,200	20·1	25·5	31·3	37·9	46·1	53·4	62	71·3	80·9
6,300	20·4	25·9	31·8	38·5	46·8	54·3	63	72·4	82·2
6,400	20·8	26·4	32·4	39·2	47·6	55·2	64	73·6	83·6
6,500	21·1	26·8	32·9	39·8	48·3	56·0	65	74·7	84·9
6,600	21·4	27·2	33·4	40·4	49·0	56·9	66	75·9	86·2
6,700	21·7	27·6	33·9	41·0	49·8	57·7	67	77·0	87·5
6,800	22·1	28·0	34·4	41·6	50·5	58·6	68	78·2	88·8
6,900	22·4	28·4	34·9	42·2	51·3	59·4	69	79·3	90·1
7,000	22·7	28·8	35·4	42·8	52·0	60·3	70	80·5	91·4

THE APPLICATION OF NOBILI'S RINGS TO COLOR PHOTOGRAPHY.

A SERIES of experiments relating to the phenomena known as "Nobili's rings" and their application to color photography was brought out in a paper presented by G. Delvalez to the Société de Physique. It was found by Nobili and afterward by Becquerel that if we make an electrolysis of a lead acetate solution upon a well-polished anode plate, we have a deposit of dioxide of lead which shows bright colors due to the thin layers which are produced, and the hue changes with the thickness. The same holds good for various metals and solutions. We can use a cathode in the form of a fine metal point and bring it quite near the polished anode plate, and thus produce brilliant colored rings. M. Delvalez applies this to color photography. Placing a sheet of polished brass in the bath and lighting each half of the plate differently, a minute current is set up between the two portions of the plate due to the unequal lighting, and this is sufficient to form a thin film of deposit. The color of the film varies with the light and the duration. If we place a negative above the brass plate and expose to the sun, we can produce an impression on the plate. The clear portions of the negative (whites) give a brown hue after five minutes, changing to purple and then to green in 15 minutes. The blacks give a violet blue color which then becomes lighter. We thus take a print of the negative on the plate in varying colors. An analogous phenomenon has been found by M. Piltschikoff. He uses a bath of zinc salt and an anode of zinc with a cathode formed of a copper plate which has a polished but slightly oxidized surface, giving a deposit of zinc on the copper plate. The deposit is different on the lighted parts of the plate from what occurs on the darkened parts. A silhouette of an object can thus be formed, and this within a small fraction of a second. Thus we have the basis for an instantaneous photo-galvanic process. It may be possible to apply these phenomena in such a way that they will have a practical value.

WILD ANIMALS IN CAPTIVITY.*

THE ZOOLOGICAL GARDENS OF NEW YORK.

So rapid and general is the encroachment of civilization upon the still wild portions of the continent to-day that the time is not inconceivably distant when these unexplored or unsettled territories will be completely given over to man. And with this slow but certain domination arises the almost inevitable assimilation of the aboriginal inhabitants and the complete extinction of the fauna, the latter usually taking place with extraordinary rapidity. An unfortunate example of these truths is the present condition of the American Indian and the American bison, the first disappearing and hopelessly degenerated, and the former countless millions of the second represented here and there by a few small herds in private parks or zoological gardens. Here, too, become evident the invaluable services of zoological collections, not only as a means of present education, but also in the preservation for our future generations of the rapidly vanishing animal species of to-day.

New York city is peculiarly fortunate in the possession of two excellent collections of this character, the old Central Park Zoo, the favorite haunt for generations of the city's children, and the splendid New York Zoological Park inaugurated a few years ago in the Bronx, and to-day comparing favorably with the foremost institutions of like character in the world. It would be too ambitious to discuss both these zoological collections in detail in this sketch, which is intended to be merely explanatory of the accompanying illustrations which were made from photographs taken at random among the animals both in Central Park and in the Bronx. One of the most attractive features of the latter institution is unquestionably found in the spacious buildings in which the animals are housed, structures not only fully answering the purpose for which they were intended, but which please the eye with their architectural beauty as well. Massive stone and handsome woodwork, glistening tiling, mosaic and quantities of appropriate plants have almost done away with the idea that the exhibition is one of caged wild animals, while the latest improvements in sanitation and ventilation have practically obviated a feature formerly so difficult to disassociate from zoological collections—the offense to the sightseer's poor nose.

These of the illustrations which were taken in Central Park are of Dewey, the patriarch of the lion house; of Jennie, the largest leopardess; of Keeper Snyder's trick elephant Hattie, and of the curious Tibetan yak. The artistic value of the first two photographs mentioned needs no remark. The splendid head of the great lion is shown in a characteristic pose which goes far toward substantiating the title "King of the Beasts." Striking, too, is the head of the great spotted cat, with its heavy light and shade effects. The muscular relaxation of its quiet dignity still does not conceal the lurking menace ever present in the inscrutable eyes. The leopard is undoubtedly one of the least reliable of the cat family, and Jennie's facial expression, quite opposite to Dewey's open defiance, does not contradict this characteristic. Keeper Snyder, who is well known to the New York public as an expert elephant trainer, is here shown putting his favorite, Hattie, through her clever paces. Hattie, despite her worried expression, is a most affable creature, and we feel sure that the difficulty of her balancing act quite warrants her perturbation of mind. The yak, photographed at the door of his domicile, is an inoffensive creature as a rule, though his undomesticated relatives of the Central Asian mountains will sometimes charge upon hunters or travelers with the utmost ferocity. To the inhabitants of Tibet, which country is Mr. Yak's native heath, he is practically invaluable, being used as a bearer of burdens where no other four-footed creature can go, his thick, soft fur supplying his master with excellent covering, while yak milk, butter, and flesh are said to be without equal as articles of food. The domestication of the yak first took place centuries ago—how many it is impossible to say—and to-day a great part of the wealth of Tibet is counted in herds of this useful animal.

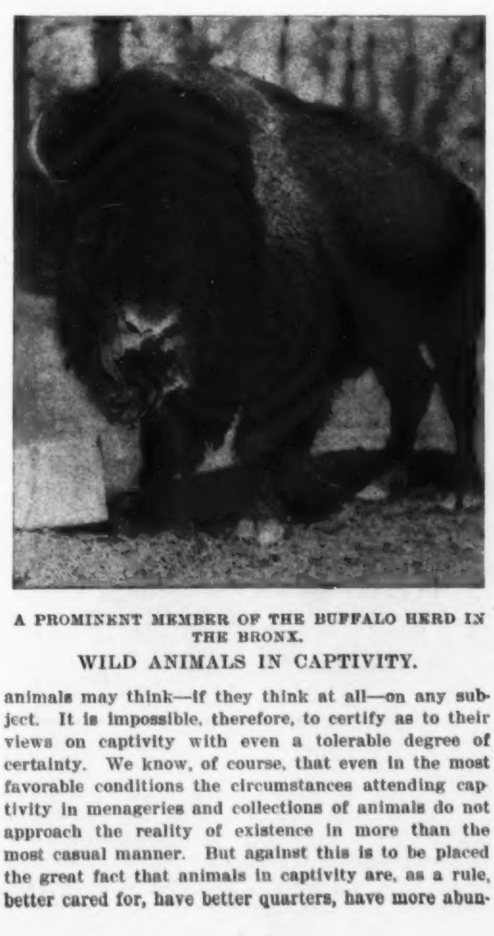
The four remaining photographs were taken in the New York Zoological Park. The buffalo is one of the largest bulls in the fine herd which the collection includes.

The great shaggy head wears a rather bored expression, for in order to take the photograph, Mr. Bison was interrupted in the pleasurable occupation of eating his lunch, and as the photograph shows, he did not even have time to use his napkin. The illustration gives the observer a good idea of the massive head and powerful fore-quarters of these wild cattle of the plains, now unfortunately practically extinct. The elephant is of about the same size as Hattie, and nearly as clever. It is used to carry the children, who obtain the exciting pleasure of an elephant ride upon the payment of a nominal sum. As the photograph was taken, the huge pachyderm was stepping over the wire fences along one of the walks, and it is ludicrous to see the almost painful carefulness with which the ponderous foot is raised so as not to injure the obstacle. The two bears are of the European brown

DEWEY, ONE OF THE FINE LIONS IN CENTRAL PARK.

variety, and are the particular friends of the keeper shown in the engraving. So peaceful and even suppliant do they look as posed for the picture that it is hard to imagine the enormous muscular effort and blind rage of which they are capable when aroused. The single bear on the rock is a very large silvertip grizzly, presented to the Park by the Engineers' Club of New York city. The grizzly is acknowledged to be one of the most powerful and ferocious animals in existence, and the appearance of that member of the family shown in the illustration does not belie these characteristics, notwithstanding that his object appears to be merely the peaceful acquisition of a peanut in the keeper's hand.

A great deal of unnecessary sentiment is unquestionably wasted on the subject of animals in captivity. If animals are truly thinking beings it is often supposed that they suffer many real as well as many imaginary harms, injuries. Nature writers to the contrary, it still remains true that we do not know what



A PROMINENT MEMBER OF THE BUFFALO HERD IN THE BRONX.

WILD ANIMALS IN CAPTIVITY.

animals may think—if they think at all—on any subject. It is impossible, therefore, to certify as to their views on captivity with even a tolerable degree of certainty. We know, of course, that even in the most favorable conditions the circumstances attending captivity in menageries and collections of animals do not approach the reality of existence in more than the most casual manner. But against this is to be placed the great fact that animals in captivity are, as a rule, better cared for, have better quarters, have more abundant food supplied with quite unnatural regularity, than any wild beast can possibly have.

Doubtless it is true enough that the animals so situated do not know this. Their natural state is free, and without their natural freedom even human care and regular food cannot successfully compete. Creature comforts, indeed, sometimes seem quite secondary to wild animals, which often enough refuse to recognize or value the care that is lavished upon them.

Modern zoological science, as typified and exemplified in the modern zoological garden, rises as completely to the requirements of natural living as it now seems possible to do. This is particularly true of the garden of the New York Zoological Society. We have, at all events, no reason to assume that the animals there housed are not treated with the most intelligent care.

* From American Homes and Gardens. Published by Munn & Co.

HUMAN ODORS.

Dogs, which have a far more acute sense of smell than is possessed by human beings, are able to follow their masters and other persons for long distances by scent, and to distinguish between the odors of different persons. For this reason dogs were formerly used in hunting runaway slaves in America, and dogs have lately been called upon to do police duty by tracking criminals. This ability of dogs to trace and distinguish persons by scent proves that every human being emits an odor which differs from those of other human beings. Most persons are unconscious of their own peculiar odors and those of other people, but a few persons are able to perceive and distinguish human odors. This faculty is strongly developed in many blind persons. The Greek philosopher Theophrastus refers to this power, Martial speaks of the fragrance of the famous beauty Thaïs, and Plutarch relates that Alexander the Great exhaled a very strong and characteristic odor which long clung to his garments. Among moderns, the Swiss physiognomist Lavater possessed exceptionally keen scent, and asserted that he could recognize many persons by their peculiar odors.

According to Prometheus, the human odor arises from the sweat and exhalations of the skin and it becomes stronger as these excretions are increased by active exercise, heat, sudorific drugs, and fear and other emotions. Both the intensity and the character of the bodily odor, furthermore, are influenced by the time of day, the condition of the nervous system, and various habits. The odor is said to vary with the color of the hair, perhaps because of odors emitted by the hair itself. Red-haired persons of both sexes are said to be especially strong-scented. Dr. Galopin, who has made minute studies of human odors, asserts that many fair-haired women exhale a faint perfume of ambergris or musk, while brown-haired women are more or less redolent of violets. An easily perceptible odor of violets is diffused by many hysterical subjects. Personal odors are affected by various diseases. Consumption, even in very early stages, is often recognizable by a characteristic odor, and the odors of other diseases are often strong enough to be detected even by persons who are not gifted with unusually keen scent.

Besides individual peculiarities of bodily odor, there are racial peculiarities, which in some cases are generally perceived and recognized. To white people the goat-like odor of negroes and the characteristic smell of Mongolians are repulsive. On the other hand, both negroes and Chinese assert that Europeans exhale a stale and corpse-like odor, and the odor of white women is especially repugnant to the Japanese.

Vegetalin can be used in the imitation of ivory, coral, rubber, leather, etc. Cellulose, of any origin preferred, is treated for some time with sulphuric acid of 580 Bé. at 60 deg. F., then washed with water until the sulphuric acid in excess is completely eliminated, dried, finely pulverized, and mixed in a mortar with resinous soap (possibly with sodium resinate) and thereupon the sodium separated out with the help of sulphate of alumina. The mass is again dried, and by means of a powerful hydraulic press shaped into cakes. The cakes thus obtained are cut into thin slices which, by means of hydraulic pressure, are pressed into the desired form. If we wish to make the hardly burnable substance perfectly non-combustible, we wash the cellulose, treated as described with sulphuric acid, with chloride of ammonium, silicate of calcium, or borate of sodium. Finally, in order to render vegetalin transparent, add glycerine or castor oil to the dry powder; coloring may be effected by means of vegetable colors. Opacity on the other hand is promoted by linseed oil transformed, by means of litharge, into a siccative; if preferred such vegetalin may be colored only by means of mineral colors.

A NOVEL ELECTRIC LOCOMOTIVE.

A SIDE-ROD ELECTRIC ENGINE.

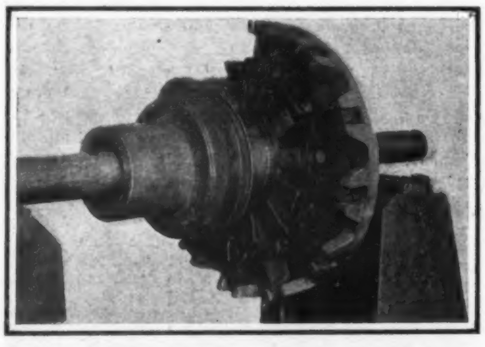
THE accompanying photographs illustrate a novel type of electric locomotive which has been designed jointly by the General Electric and American Locomotive companies for trying out a scheme of transmitting power from the motors to the drivers through side rods instead of by the ordinary methods.

The locomotive is designed for a tractive effort of 30,000 pounds at a speed of 18 miles per hour, with a maximum speed of 50 miles per hour, and will operate equally well in either direction. It has been tested with temporary motors of a somewhat smaller capacity, and the tests have demonstrated conclusively that the design is entirely satisfactory in every way. It is proposed to extend the cab over the entire length of the machine when the proper motors are installed on the locomotive. The present cab and guards are only for the temporary protection of the apparatus now installed.

One of the principal alvantages found in this type of construction is that a motor of large diameter and small air gap can be used in conjunction with small diameter driving wheels, and at the same time the motor can be spring supported. The motor bearings can be very easily designed to maintain the small air gap. Such a form of construction will also secure a marked economy in the construction of the motors, as the same horse-power can be obtained in two motors at a less cost and for less weight than in four smaller motors. The same motor equipment can also be used on locomotives with different diameters of driving wheels. This feature makes possible the interchange of equipment on roads where both freight and passenger locomotives of this type are employed. This type of locomotive is as well adapted for operation with direct current motors as with those of the alternating current type.

The motors in such a locomotive can be located so as to concentrate a greater proportion of the weight near the center of the machine with the attendant advantage that the moment of inertia of the locomotive around its vertical axis will be as small as possible. This will reduce the rail pressures at the leading and trailing wheels and consequently the flange and railhead wear.

The location of the motors in the cab facilitates inspection and repairs and the renewal of brushes. The maintenance charges for the motors will also be greatly reduced as practically all road dust and other foreign material can be kept out.

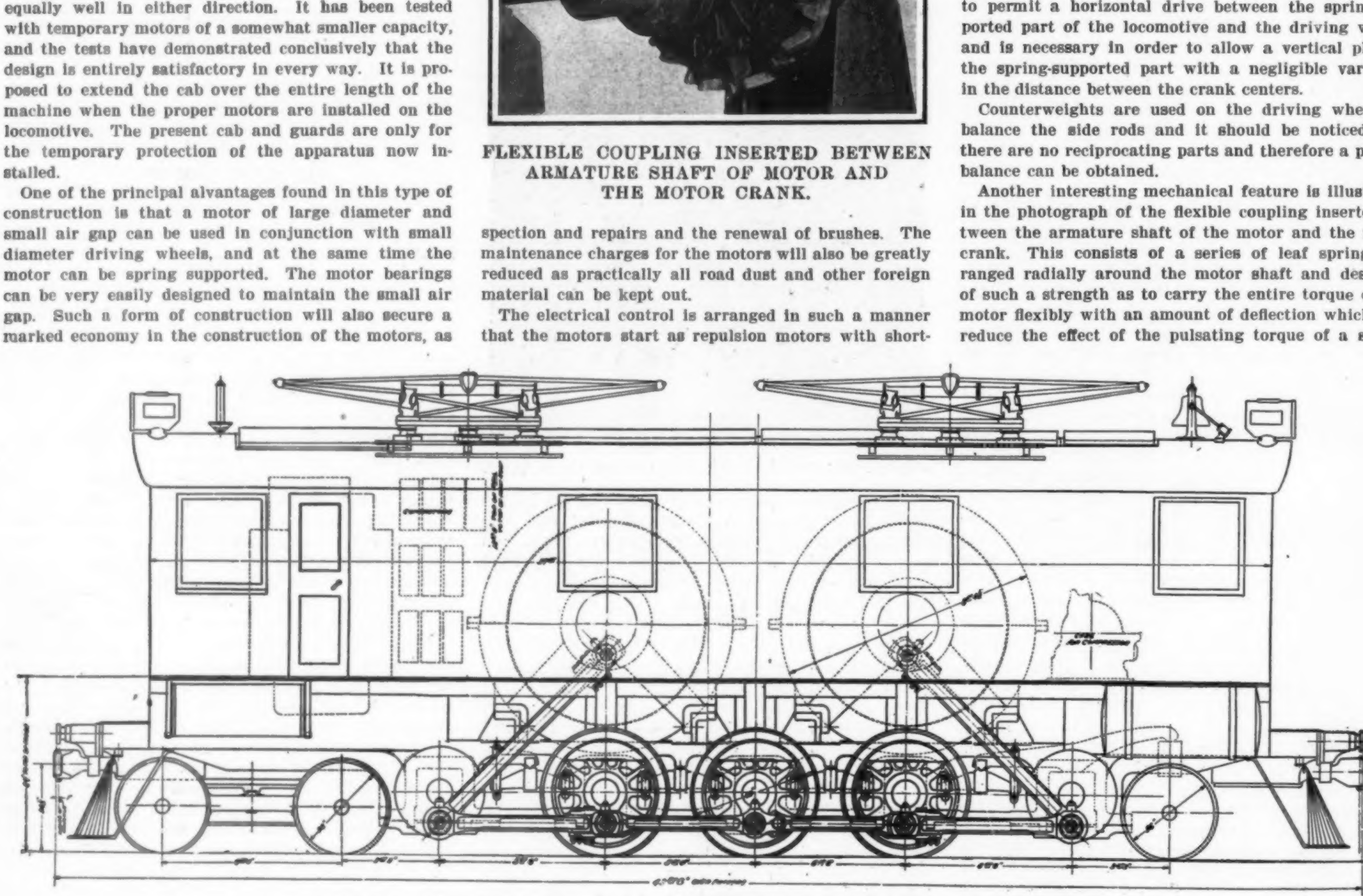


FLEXIBLE COUPLING INSERTED BETWEEN ARMATURE SHAFT OF MOTOR AND THE MOTOR CRANK.

The electrical control is arranged in such a manner that the motors start as repulsion motors with short-circuited armatures and are changed over to series repulsion motors for the higher speeds. This arrangement eliminates running with a short-circuited armature on high voltage and at the same time gives a high torque at starting. In fact the tractive effort is about twice as great with repulsion motor connections as with series repulsion connections for a corresponding current value.

The armatures are similar to those of an ordinary direct-current machine with equalizer rings. They have multiple drum windings with the bars soldered directly into the commutator segments.

The field of stationary windings is of the distributed type and they are made in two sections—exciting and inducing windings. The former has the same function as the field winding in an ordinary series motor, while the inducing winding introduces the working torque when the motor is connected as a repulsion motor.



PARTIAL LONGITUDINAL SECTION THROUGH THE SIDE-ROD LOCOMOTIVE.

All parts of the running gear, such as wheels, driving boxes, axles, springs, spring rigging, trucks, etc., follow standard steam locomotive practice.

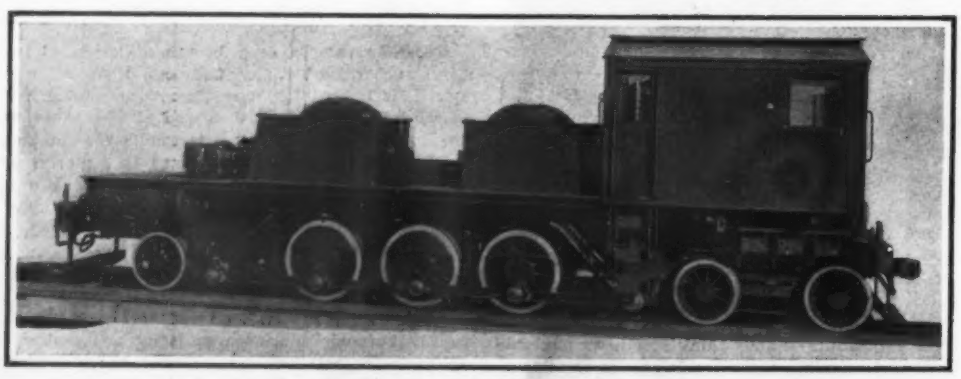
The arrangement of the side rods is shown in the illustrations and it will be noticed that each motor is coupled to a jack shaft and thence to the drivers. The jack shaft bearings are rigid in the spring-supported locomotive frame and their centers are on a level with those of the drivers. The object of this jack shaft is to permit a horizontal drive between the spring-supported part of the locomotive and the driving wheels and is necessary in order to allow a vertical play of the spring-supported part with a negligible variation in the distance between the crank centers.

Counterweights are used on the driving wheels to balance the side rods and it should be noticed that there are no reciprocating parts and therefore a perfect balance can be obtained.

Another interesting mechanical feature is illustrated in the photograph of the flexible coupling inserted between the armature shaft of the motor and the motor crank. This consists of a series of leaf springs arranged radially around the motor shaft and designed of such a strength as to carry the entire torque of the motor flexibly with an amount of deflection which will reduce the effect of the pulsating torque of a single-phase alternating-current motor to a minimum.

The more important data are given below:

Trolley voltage	10,000
Cycles	15
Rated tractive effort..............	33,000 pounds
Speed at rated amperes...........	18 m. p. h.
Total horse-power	1,600
Number of motors.................	2
Type of motor....................	GEAZ—43
Diameter of driving wheels........	49 inches
Number of driving wheels.........	6
Diameter of pony wheels..........	36 inches
Diameter of bogie wheels..........	36 inches
Total wheel base..................	33 feet 6 inches
Rigid wheel base..................	10 feet
Length, total	43 feet 6 inches
Height	13 feet 8 inches
Weight on drivers................	162,000 pounds
Weight per axle, driving..........	54,000 pounds
Total weight......................	250,000 pounds



THE NEW ELECTRIC SIDE-ROD LOCOMOTIVE.

A very important trade is now done by the extraction of tin from waste tins and the cuttings of tinplate, both on the Continent and in the United States. The process of electrolysis is employed. The electrolyte consists of a soda solution, and the waste forms the anode. The tin becomes oxidized, and is then dissolved in the electrolyte. The hydrogen thereupon reduces the oxide, and the metallic tin is deposited on the cathode. The iron freed from the tin may subsequently be used again. It is said that in Germany 75,000 tons of residues yield annually 1,500 tons of tin, and that the amounts dealt with in America are 60,000 tons per year, and in the other European countries, exclusive of Germany, 25,000 tons. In all, some 3,000 to 3,500 tons of tin are recovered annually by these means from 160,000 tons of waste, which is about 3 to 3½ per cent of the total amount of the world's tin supply.

THE ASTRONOMICAL CLOCK AT LYONS.

A WONDERFUL TIMEPIECE.

BY CHARLES A. BRASSLER.

The ancient astronomical clock in the cathedral of St. Jean at Lyons, France, shown in our illustrations, is incontestably, if not the most beautiful, at least one of the most beautiful monuments of early horology that exists. It exhibits, at all events, one peculiarity not common to many of the other old clocks, which is that it is still running, as far as its essential organs are concerned, and is not resting quietly behind the glass of some conspicuous case in a museum. The old clock has recently been overhauled and repaired by the well-known firm of Chateau Frères & Cie., Paris.

If we are to believe the text of the inscription from the seventeenth century which accompanies an old cut, this clock dates back only to 1660. It assures us that in that year the lord canons of Lyons installed it. In reality they only had it repaired at that period.

More than one hundred years before that date it was already in existence, since an act of the chapter expressly declares that in 1572 "it did not run any more"! Again in 1598 the whole system was put in a state of complete order by Nicolas Lippius, a renowned mathematician of Basle, who was called to the work by the horologist Hugues Levet, of Lyons, to whom the canons had confided a task which he himself was incapable of performing. In 1660 the restoration mentioned in the inscription was effected by Guillaume Nourrisson, whose name is engraved upon the front of the base. In 1779 Charmy undertook anew the task of repairing it, and during the course of his work he added to it a Graham escapement (1782). From the Revolution until 1894 the poor old clock was doctored by several pseudo-horologists, who fairly massacred it without being able to make it go. Finally in 1894 the Chateau Brothers, watch and clock makers at Paris, undertook its complete restoration, and succeeded so well that it has been running regularly ever since.

THE AUTOMATICALLY OPERATED FIGURES OF THE FAMOUS LYONS CLOCK.

The total height of the monument is about 10 meters, or something over 30 feet. The pendulum, which measures 9 feet useful length, regulates the movement, which actuates the hand of the oval dial for the minutes, that is visible to the right of one of our illustrations; also all that part of the astronomical works that we find enlarged in another cut, and which comprise a calendar and a very complete astrolabe.

The striking work contains a small chime tuned to the ordinary scale, and the hour strike work trips the rods of this chime. Finally, the clock is completed by the addition of divers automata—a cock that crows being placed upon the very summit of the structure, a beadle who approaches to make his rounds, and statuettes that represent the days of the week. While the chimes are playing, an angel beats the time with her wings, her head, and her foot. When the chimes have done, another angel turns an hourglass. Although the automata are interesting and even entertaining, we shall not dilate further upon their play, which closely resembles that of all the ancient automata, but we shall devote our time to the more enlightening consideration of the astronomical features. They are comprised, as we have said, in the two dials on the front of the clock, but particularly on the upper one, the lower one being reserved for the calendar.

The calendar, which provides the changes for 66 years, is built up of a crown having an outside diameter of 5 feet and an interior diameter of about 3 feet. It is divided into 365 divisions radiating from the center. Made of wood, it is covered with parchment. Each division indicates a day of the year in the ordinary and also in the Roman calendar; besides that, the festival for each day is added. At the close of the year an outside disk measuring 3 feet in circumference and divided into 66 parts moves up one notch, and changes thus the general figures for the year, visible through a vertical slot, which may be distinguished in one cut. These figures are the yearly dates, and they run up to 1959, the number of the Sundays after the Epiphany and Pentecost, the Septuagesima Sunday, Easter, Pentecost, the Ascension, the feast of the Holy Sacrament, the first Sunday in Advent, the Dominical Letter, the Golden Number, the Epact, the Roman Indiction, and the Martyrological Letter.

As for the astrolabe, it is composed of several parts, one of them fixed, the others movable. The fixed portion is represented herewith. It is what the Arabs called a *safiha*, and called during the middle ages a tympanum. It is a stereographic projection of a hemisphere, of which the zenith of Lyons forms the summit. The plane of the projection is tangent to the sphere at the North Pole, and the point of view is taken at the South Pole. The three concentric circles extending over the surface from the outer edge of the center represent the tropic of Capricorn, the equator, and the tropic of Cancer. The hemisphere is marked off in meridians 10 degrees apart and in parallels 5 degrees apart. The first of the parallels, that which forms the limit of the projected hemisphere,

FRONT DIAL OF ASTROLABE AND CALENDAR.

LA SAFIHA.

FRONT VIEW OF THE LYONS CLOCK.

was called among the Arabs the first of the *almonquantarat*. There is on this surface another parallel drawn in about 18 deg. from the first of the *almonquantarat*. This is the limit of twilight. The vertical straight line is the meridian of Lyons. It is the line of the *zaoual*, or the true noontide. The right line which cuts this at right angles is the east and west line. The divisions marked in the lower half of the *safiha* by Roman numerals represent the *unequal* hours, while the divisions in the upper half, and distinguished by Arabic numerals, mark the *Houses of the Heavens*.

The movable parts of the astrolabe are the *ul'ankaboui*, *aranea*, and the *alidada*. Their form is sufficiently presented in detail herewith. The clock actuates the *alidada* by means of a large wheel with 240 teeth. This *alidada* turns through 24 hours, which are painted on the border surrounding the dial and forming a part of the cabinet. The *alidada* is also provided with a longitudinal slot, which affords an easy passage of a block, upon the very top of which is fixed a picture of the sun, the lower extremity of the block sliding easily in an eccentric groove which represents the ecliptic. The *aranea* is driven by a train of differential gears and turns a little faster than the *alidada mediclinium*, and just fast enough to gain one revolution in 366 days and 6 hours. In this manner the sun taking part in the movement of both the *alidada* and the *aranea* moves back upon the sphere one day for each sidereal year, which produces its true movement.

Upon the *aranea* are to be found divisions corresponding to 365 days. There are also the twelve months of the year and the twelve zodiacal signs, a scale of 360 deg., the eccentric circle of the ecliptic, and a further scheme of decoration, whatever may be its name, upon which are fixed in their respective places the twenty-six principal stars in the projected hemisphere. The moon is also moved by a differential train of gears, which causes it to make one turn more than the *alidada* in 29½ days. This latter carries also a small circle divided into 29½ parts, and wherever it is found under the satellite, it indicates its exact age.

We shall add for the benefit of those who may be interested in the science of astrology that the Houses of the Heavens are thus named: The House of Life, of Riches, of Brothers, of Parents, of Children, of Health, of Marriage, of Death, of Piety, of Office, of Friends, and of Enemies.

It must be added that these divisions have long since disappeared. It remains nevertheless that the astrolabe of Lyons is the most curious that has come down to us, and for that reason alone the clock should be rescued from oblivion and accorded more than a passing mention.

The cathedral in which this clock stands is one of the most famous in France, and one, moreover, of the most interesting in the south. Notwithstanding that Lyons is a city frequently visited by Americans and Englishmen, it is comparatively little known. The church is of small size but highly interesting. It was built chiefly at the end of the twelfth century, but was continued in the thirteenth and fourteenth, and was completed, with its main front, in the fifteenth century. Its Bourbon chapel is an extraordinarily rich example of late Gothic architecture. The cathedral abounds in historic associations, and contains many rich and splendid works of art. This clock is one of its most remarkable possessions.

THE INDESTRUCTIBILITY OF MATTER.

SOME VIEWS ON THE CONSERVATION OF MASS.

BY PROF. G. ZENGHELIS.

The law of indestructibility of matter, or as it is technically called, of conservation of mass, forms the very foundation stone of modern chemistry. For that science may be said to date from the time when Lavoisier introduced the balance for the investigation of all chemical reactions, and established the law that in every reaction the total weight of the reacting substances is the same before and after the transformation. This same law had been stated previously, no less than twenty-three centuries before, by the Greek philosophers Anaxagoras, Aristotle, Empedocles, and Democritus. The last mentioned, for example, says: "Nothing can arise out of nothing, and nothing can ever be destroyed; all the events which occur in the world consist in changes of form, in the mixing and separating of bodies; the essence of nature is a perpetual cycle."

No attempt was, however, made by the philosophers of antiquity to apply these ideas to every-day phenomena, or to test rigorously the truth of the law. To Lavoisier belongs the credit of having given the true interpretation of the process of combustion, through the aid of the balance, his sure guide in all chemical operations.

Neither Lavoisier, however, nor the later chemists deemed it necessary to put the principle to a crucial test. For in every chemical reaction and every analysis its truth was so plainly demonstrated that it seemed unnecessary to seek for further proof.

Nevertheless, in connection with certain operations which call for the highest degree of accuracy, as in the determination of atomic weights, the question of the absolute truth of the law has been raised. Thus Stass found that in the synthesis of silver bromide and iodide from their elements, the mass of the product always fell by a few milligrammes below the sum of masses of the constituents. The losses ranged from one twenty-thousandth to one seventy-two-thousandth of the total weight. From the point of view of theory also some doubts were expressed as to the absolute constancy of mass, by those who considered the several elements as composed of "protyl," i. e., of one ultimate or fundamental element.

Kreichgauer was the first to make actual experiments with a view to elucidating the point, and the matter was taken up after him by others. Foremost among these investigations stands the work of Landolt. He experimented with reactions which take place in aqueous solution. The reagents were placed in sealed glass tubes, and the experiments were conducted in masterly fashion, with the most extreme precautions, so as to eliminate or correct for every imaginable source of error. The work was begun in 1893. Later, in 1901, when a new balance of the greatest precision, specially constructed for this purpose, was in readiness, Landolt repeated his experiments. The result was, that in 42 out of 54 cases there was found to be a loss in weight. The greatest loss occurred in the case of the reaction between ferrous sulphate and silver nitrate, and between iodic and hydriodic acid. It amounted to 0.069 to 0.199 milligramme. In view of the extreme care with which the work was carried out—the error in weighing did not exceed 0.03 milligramme in 300 grammes—we are forced to the conclusion that there must have been an escape of some of the matter in the tube through the glass walls. Landolt himself is in favor of this view. Following up this point the author then conducted a series of experiments to determine whether there actually are gases or vapors which are capable of diffusing through glass. For this purpose use was made of a very delicate test for traces of metallic and other vapors. This consists in exposing to the suspected vapor leaves of very fine silver foil. If such silver foil is, for example, suspended in a closed vessel over a solid substance, say a metallic oxide or salt, or the powdered metal itself, the foil after some time becomes visibly attacked and tarnished by the vapor emitted from the solid. The substances to be examined were inclosed in fused glass vessels. Pieces of silver foil were attached to the outer surface of the containing vessel, and the latter was then placed under a bell jar resting upon a glass plate, to which the jar was sealed by means of paraffin wax. In this way over fifteen substances were examined, among them those with which Landolt has observed the greatest losses. The attack of the silver foil was plainly evident to the eye and was confirmed qualitatively, and in some cases quantitatively, by analysis.

These experiments showed conclusively that many gases or vapors, even those given off by solid bodies, are capable of diffusing through glass. This faculty does not stand in any direct relation to the volatility of the substance. Thus iodine passes through glass more readily than chlorine or bromine. Reduced pressure and a small thickness of the glass walls largely promote the effect. It is probable that a vapor, in order to be capable of passing through glass, must first undergo a dissociation or disintegration. This would be quite in accordance with a number of phenomena which have been observed. According to Thomson, most substances give off emanations, which must be regarded as products of the disintegration of matter. Rutherford supposes that there are transformations similar to radioactive transformations, but unaccompanied by the emission of active rays.

It is therefore very probable that the products of disintegration of gases and vapors pass through the pores of the glass, just as cathode rays do. These latter also have very small mass and are transmitted by the glass.

Helium also possesses in a high degree the faculty of diffusing through glass, and it is well known that hydrogen passes readily through iron.

These facts serve to explain the losses of weight observed by Landolt. At the same time they point to the occurrence of processes by which matter is disintegrated into particles more elementary than the atoms. The supposition that such processes might occur has of late years been substantiated by the study of radio-active bodies, but it had already previously been rendered plausible by experimental observations.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

THE LIFE OF A COMET.

In an article by Mr. A. C. D. Crommelin, F. R. A. S., which appears in the current number of Science Progress, and which deals with the expected return of Halley's Comet, he remarks on some aspects of resemblance between Halley's Comet at its appearance in 1835 and the Comet Morehouse. The nucleus in each case appeared to be in a state of great activity, and ejected streams of matter in various directions with a violence that has been compared to a volcanic outburst. These streams are at once repelled by the sun, the repulsive force being either of an electrical nature or being simply the action of light on very finely divided matter. "The main tail is directed almost exactly away from the sun, but there are a number of lateral tails or brushes making various angles with this. It was shown by Bessel that some of the changes could be explained by supposing that the comet was rotating in about five days. A similar suggestion was made for Comet Morehouse. . . . Another feature that Halley's Comet in 1835 shared with the Comet Morehouse was that both at times lost their tails for a short period. Since we may be sure that the sun's repulsive action did not cease, we must suppose that this arose from some change in the head of the comet, the nature of which we cannot guess. Comet Morehouse seemed to have a fairly regular cycle of changes, so that it was even possible to predict when the tail was likely to disappear, and when a new outburst was likely to occur."

An almost continuous series of photographs was obtained of Comet Morehouse through the co-operation of several observatories; and we have yet to receive those which were made in the Southern Hemisphere after the comet had passed beyond the reach of northern observers. A most striking series of photographs was obtained by the Rev. Joel Metcalf at the Observatory, Taunton, Mass., and these have been published by Harvard College Observatory. The instruments employed by Mr. Metcalf were two doublets of his own construction. The first of these has an aperture of 12 inches, and a focal length of 87.5 inches. The second doublet has an aperture of 5.8 inches, and a focal length of 20 inches. The method which he has used so successfully, in discovering and following asteroids, was employed after September 15th. The cross wires of a finding telescope were kept upon the image of a star, while the plate was moved every minute, by an amount, and in a direction, equal to the theoretical motion of the comet as determined from its ephemeris. This method proved particularly advantageous, since this comet had no well defined nucleus which could be used for following in the ordinary way. The effectiveness of the method is shown by the smoothness of the trails of the stars. In all cases, two photographs were obtained simultaneously with these telescopes, except on November 12th, when the smaller instrument only was used.

By observation of the several features of the tail it was possible to trace their direction and speed as they were repelled from the head of the comet. The repulsive force was shown to be considerably stronger than gravitation, so that clearly the comet loses altogether what the head appears to part with; and it is easy to understand why Halley's Comet has appeared less terrific at recent returns (and probably may be quite insignificant in appearance next year) than when it struck dismay into the minds of people some centuries ago. Mr. Crommelin thinks that Halley's Comet will almost certainly be found this autumn; and he thinks that the most probable date of its perihelion passage will be April 16th, 1910. It will be nearly stationary in Pisces in January and February, and probably visible with small telescopes, possibly even with the naked eye. It will then pass behind the sun, being a fairly bright morning star in April and the beginning of May. It will again pass the sun on May 17th, and for a few days after this may be expected to be at its greatest splendor, and distant only twelve millions of miles from the earth. It is likely then to make its best display in the Southern Hemisphere.—Knowledge and Scientific News.

AERIAL FLIGHT.

A SUMMARY OF F. W. LANCHESTER'S VIEWS.

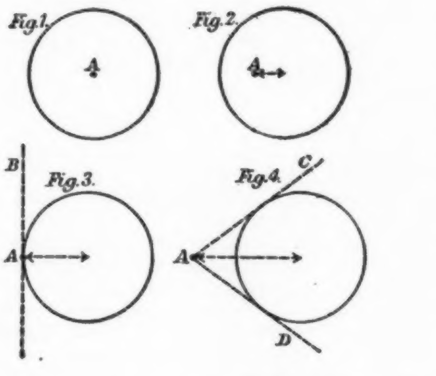
IN opening on Monday, May 10th, 1909, at the rooms of the Royal Society of Arts, the concluding lecture of his course on "Aerial Flight," Mr. F. W. Lanchester said that practical flight was not the abstract question which some apparently considered it to be, but a problem in locomotive engineering. The flying machine was a locomotive appliance, designed not merely to lift a weight, but to transport it elsewhere, a fact which should be sufficiently obvious. Nevertheless one of the leading scientific men of the day advocated a type in which this, the main function of the flying machine, was overlooked. When the machine was considered as a method of transport, the vertical screw type, or helicopter, became at once ridiculous. It had, nevertheless, many advocates who had some vague and ill-defined notion of subsequent motion through the air after the weight was raised. When efficiency of transport was demanded, the helicopter type was entirely out of court. Almost all of its advocates neglected the effect of the motion of the machine through the air on the efficiency of the vertical screws. They either assumed that the motion was so slow as not to matter, or that a patch of still air accompanied the machine in its flight. Only one form of this type had any possibility of success. In this there were two screws running on inclined axles —one on each side of the weight to be lifted. The action of such inclined screw was curious, and in a previous lecture he had pointed out that it was almost exactly the same as that of a bird's wing. In high-speed racing craft such inclined screws were of necessity often used, but it was at a sacrifice of their efficiency. In any case the efficiency of the inclined-screw helicopter could not compare with that of an aeroplane, and the type might be dismissed from consideration so soon as efficiency became the ruling factor of the design.

To justify itself the aeroplane must compete, in some regard or other, with other locomotive appliances, performing one or more of the purposes of locomotion more efficiently than existing systems. It would be no use unless able to stem air currents, so that its velocity must be greater than that of the worst winds liable to be encountered. To illustrate the limitations imposed on the motion of an aeroplane by wind velocity, Mr. Lanchester gave the diagrams shown in Figs. 1 to 4. The circle in each case was, he said, described with a radius equal to the speed of the aeroplane in still air, from a center placed "down wind" from the aeroplane by an amount equal to the velocity of the wind. Fig. 1 therefore represented the case in which the air was still, and in this case the aeroplane represented by *A* had perfect liberty of movement in any direction. In Fig. 2 the velocity of the wind was half that of the aeroplane, and the latter could still navigate in any direction, but its speed against the wind was only one-third of its speed with the wind. In Fig. 3 the velocity of the wind was equal to that of the aeroplane, and then motion against the wind was impossible; but it could move to any point of the circle, but not to any point lying to the left of the tangent *A B*. Finally, when the wind had a greater speed than the aeroplane, as in Fig. 4, the machine could move only in directions limited by the tangents *A C* and *A D*.

Taking the case in which the wind had a speed equal to half that of the aeroplane, Mr. Lanchester said that for a given journey out and home, down wind and back, the aeroplane would require 30 per cent more fuel than if the trip were made in still air; while if the journey was made at right angles to the direction of the wind, the fuel needed would be 15 per cent more than in a calm. This 30 per cent extra was quite a heavy enough addition to the fuel; and to secure even this figure it was necessary that the aeroplane should have a speed of twice that of the maximum wind in which it was desired to operate the machine. Again, as stated in the last lecture, to insure the automatic stability of the machine it was necessary that the aeroplane speed should be largely in excess of that of the gusts of wind liable to be encountered. There was, Mr. Lanchester said, a loose connection between the average velocity of the wind and the maximum speed of the gusts. When the average speed of the wind was 40 miles per hour, that of the gusts might be equal or more. At one moment there might be a calm or the direction of the wind even reversed, followed, the next moment, by a violent gust. About the same minimum speed was desirable for security against gusts as was demanded by other considerations. Sixty miles an hour was the least figure desirable in an aeroplane, and this should be exceeded as much as possible. Actually, the Wright machine had a speed of 38 miles per hour, while Farman's Voisin machine flew at 45 miles per hour. Both machines were extremely sensitive to high winds, and the speaker, in spite of newspaper reports to the contrary, had never seen either flown in more than a gentle breeze. The damping out of the oscillations of the flight path, discussed in the last lecture, increased with the fourth power of the natural velocity of flight, and rapid damping formed the easiest, and sometimes the only, defense against dangerous oscillations. A machine just stable at 35 miles per hour would have reasonably rapid damping if its speed were increased to 60 miles per hour.

It was, the lecturer proceeded, inconceivable that any very extended use should be made of the aeroplane unless the speed was much greater than that of the motor car. It might in special cases be of service, apart from this increase of speed, as in the exploration of countries destitute of roads, but it would have no general utility. With an automobile averaging 25 to 35 miles per hour, almost any part of Europe, Russia excepted, was attainable in a day's journey. A flying machine of but equal speed would have no advantages, but if the speed could be raised to 90 or 100 miles per hour, the whole continent of Europe would become a playground, every part being within a daylight flight of Berlin. Further, some marine craft now had speeds of 40 miles per hour, and efficiently to follow up and report movements of such vessels an aeroplane should travel at 60 miles per hour at least. Hence from all points of view appeared the imperative desirability of very high velocities of flight. The difficulties of achievement were, however, great.

As shown in the first lecture of his course, the resistance to motion was nearly independent of the velocity, so that the total work done in transporting a given weight was nearly constant. Hence the question of fuel economy was not a bar to high velocities of flight, though should these become excessive, the body resistance might constitute a large proportion of the total. The horse-power required varied as the velocity, so the factor governing the maximum velocity of flight was the horse-power that could be developed on a given weight. At present the weight per horse-power of feather-weight motors appeared to range from $2\frac{1}{4}$ pounds up to 7 pounds per brake horse-power, some actual figures being as follows:



Antoinette	5 lbs. per B. H.-P.
Fiat	3 lbs. per B. H.-P.
Gnome	Under 3 lbs.
Metallurgic	8 lbs.
Renault	7 lbs.
Wright	6 lbs.

Automobile engines, on the other hand, commonly weighed 12 pounds to 13 pounds per brake horse-power.

For short flights fuel economy was of less importance than a saving in the weight of the engine. For long flights, however, the case was different. Thus, if the gasoline consumption was ½ pound per horse-power hour, and the engine weighed 3 pounds per brake horse-power, the fuel needed for a six-hour flight would weigh as much as the engine, but for half an hour's flight its weight would be unimportant.

The best method of propulsion was by the screw, which acting in air was subject to much the same conditions as obtained in marine work. Its efficiency depended on its diameter and pitch and on its position, whether in front of or behind the body propelled. From this theory of dynamic support, Mr. Lanchester proceeded, the efficiency of each element of a screw propeller could be represented by curves such as were given in his first lecture (page 599 *ante*), and from these curves the over-all efficiency of any proposed propeller could be computed, by mere inspection, with a fair degree of accuracy. These curves showed that the tips of long-bladed propellers were inefficient, as was also the portion of the blade near the root. In actual marine practice the blade from boss to tip was commonly of such a length that the over-all efficiency was 95 per cent of that of the most efficient element of it. From these curves the diameter and appropriate pitch of a screw could be calculated, and the number of revolutions was then fixed. Thus, for a speed of 80 feet per second the pitch might come out as 8 feet, in which case the revolutions would be 600 per minute, which might, however, be too low for the motor. It was then necessary either to gear down the propeller, as was done in the Wright machine, or, if it was decided to drive it direct, to sacrifice some of the efficiency of the propeller. An analogous case arose in the application of the steam turbine to the propulsion of cargo boats, a problem as yet unsolved. The propeller should always be aft, so that it could abstract energy from the wake current, and also so that its wash was clear of the body propelled. The best possible efficiency was about 70 per cent, and it was safe to rely upon 68 per cent.

There was, Mr. Lanchester proceeded, some possibility of the aeronaut reducing the power needed for transport by his adopting the principle of soaring flight, as exemplified by some birds. There were, he continued, two different modes of soaring flight. In the one the bird made use of the upward current of air often to be found in the neighborhood of steep vertical cliffs. These cliffs deflected the air upward long before it actually reached the cliff, a whole region below being thus the seat of an upward current. Darwin has noted that the condor was only to be found in the neighborhood of such cliffs. Along the south coast also the gulls made frequent use of the up currents due to the nearly perpendicular chalk cliffs along the shore. In the tropics up currents were also caused by temperature differences. Cumulus clouds, moreover, were nearly always the terminations of such up currents of heated air, which, on cooling by expansion in the upper regions, deposited their moisture as fog. These clouds might, perhaps, prove useful in the future in showing the aeronaut where up currents were to be found. Another mode of soaring flight was that adopted by the albatross, which took advantage of the fact that the air moved in pulsations, into which the bird fitted itself, being thus able to extract energy from the wind. Whether it would be possible for the aeronaut to employ a similar method must be left to the future to decide.

In practical flight difficulties arose in starting and in alighting. There was a lower limit to the speed at which the machine was stable, and it was inadvisable to leave the ground till this limit was attained. Similarly, in alighting it was inexpedient to reduce the speed below the limit of stability. This fact constituted a difficulty in the adoption of high speeds, since the length of run needed increased in proportion to the square of the velocity. This drawback could, however, be surmounted by forming starting and alighting grounds of ample size. He thought it quite likely in the future that such grounds would be considered as essential to the flying machine as a seaport was to an ocean-going steamer or as a road was to the automobile.

Flying machines were commonly divided into monoplanes and biplanes, according as they had one or two supporting surfaces. The distinction was not, however, fundamental. To get the requisite strength some form of girder framework was necessary, and it was a mere question of convenience whether the supporting surface was arranged along both the top and the bottom of this girder, or along the bottom only. The framework adopted universally was of wood braced by ties of pianoforte wire, an arrangement giving the stiffness desired with the least possible weight. Some kind of chassis was also necessary. In the Voisin machine this was of bicycle tubing brazed together. The road wheels were arranged castor fashion, so that in the preliminary run during starting they did not in any way guide the machine. To obtain engines of the lowest weight every kind of device had been adopted, including copper-deposited water jackets, cast aluminium heads with steel valve seats let in, and cylinders and pistons whittled out of solid blocks of nickel steel.—Engineering.

Too much reliance is often placed by the management of our mines on the supposed security of ample ventilation. The most disastrous explosions caused by windy or blow-out shots in the mines have occurred when the ventilation was of superior character. This is natural, as the oxygen in the good ventilating current aids in the quick ignition and combustion of the carbon mon-oxide gas given off by the incomplete combustion of the powder.

AN APPARATUS FOR STUDYING FRICTION.

A DESCRIPTION OF THE DERIHON APPARATUS.

WHILE it is often quite necessary in designing machinery to know the different values for the friction of metals and the amount of wear which they will undergo in certain conditions, there does not appear to be any very satisfactory method for obtaining practical results in this direction. The given co-efficients of friction do not seem to be relied upon to any great extent by engineers, owing to the fact that the figures are not concordant or on the other hand that they will not hold good in practical work. It is found at the same time that the hardness of a metal does not correspond to any great extent with its action when under wear. Thus we have the example of Babbitt or other metals, which stand friction better than harder metals like bronze and even steel. What is needed is an instrument that will give the behavior of metals under friction and at the same time be a practical device that reproduces to some extent the real conditions.

Such an instrument has been devised by a prominent Belgian engineer, M. G. Derihon, who is at the head of an important metallurgical works at Liége. The essential principles of the Derihon apparatus are shown in the diagram Fig. 1. Inside a tight casing there is a hard steel disk *O* which is made to rotate at a given speed by means of a suitable motor. Friction is produced between the steel disk and the specimen *V* which is to be tested. The latter is in the form of a rod or short bar which can be cut to the desired section. In order to work with a constant and known pressure upon the sample, the latter is kept pressed down upon the rotation disk by means of the lever *A B C*, whose point is at the fixed point *A*, while the weight is placed at the end of the long arm at *C*. The wear which is produced upon the test bar *V* by the rotating disk causes the former to descend gradually, and the effect of the descent can be observed at the end of the long arm, at the pair of contact points *L N*. Should the ratio between the two arms of the lever be made equal to one-tenth, the point *L* will descend ten times as fast as the test bar, and thus the effect of the wear can be better noticed. In order to give an exact measurement of the wear, a micrometer device is placed at *N*, the contact point being carried at the end of a screw, which at the top carries a graduated plate *K*. The latter is made to work with a vertical scale on the left. In practice the measurement of the wear is carried out by means of an electric contact between the two points *N* and *L*. When the point *L* has become lowered by the friction, we turn the micrometer screw (which is now separated from its former contact with *L*) so that it is also lowered and touches *L*. This movement is observed by means of a galvanometer or other suitable device which is connected in the circuit of the two points. Should the micrometer screw be arranged so as to read within 1/3000 of an inch, and the lever ratio be 1 to 10, the readings for the actual wear of the test bar will therefore be within 1/30,000 inch.

In practice the lever *A B C* is supported by a secondary device which consists of a lever *F D*, pivoted about the fixed point *E*. At the outer end of the lever is a counterweight *Q*. A vertical strap *G* is placed so as to be supported at the upper part on the end of the lever *F D* and at the lower part it carries a projection which serves to support the point *B*, and is placed between this point and the test bar. This secondary system is not essential for the principle of the apparatus, but in practice it is found convenient for working the device for different reasons. It serves to give the equilibrium of the main lever when the test bar is removed and the instrument is not employed.

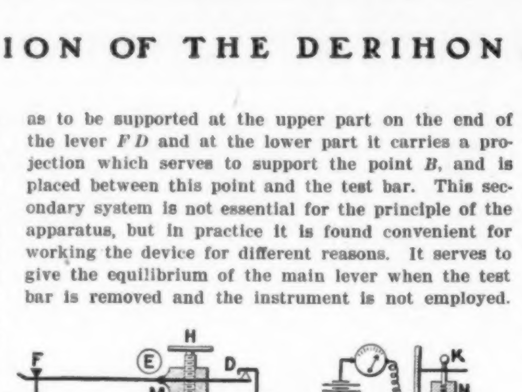


FIG. 1.—DIAGRAMMATIC VIEW OF THE APPARATUS.

At the same time the pressures are directly calculated from the weight placed at *P*. It forms a better means of connecting the main lever with the test bar, as in any case a movable piece is needed between the two, and in the present case such piece, represented by *G*, is always kept in the vertical position. This will be better understood by referring to the complete view of the machine, Fig. 2. The screw *H* is used to bring the main lever to the horizontal position after the test piece is mounted in place.

Oil is placed in the lower part of the main chamber at *R* and serves to lubricate the friction point between the disk and the sample. The machine is driven by an electric motor coupled directly on the shaft of the machine, and by varying the motor speed it is possible to obtain a wide range of motion for the tests. In the present case the speeds can be varied between 500 and 3,200 revolutions per minute, employing the usual speed indicators for taking the result. As the presence of vibrations would interfere quite seriously with the proper working of such a machine, measures are taken to overcome these effects. As will be noticed in the general view of the apparatus, the main lever is connected to a dash-pot device for this purpose, using a bearing *S* which is connected by two rods to a plunger *T* in an oil dash pot. A gage is furnished to permit of preparing the oil at a fixed level. The speed, oiling and temperature must be kept constant during the experiment. As will be noticed in the sectional view, Fig. 3, there is a water jacket around the main chamber in which the circulation is maintained at a constant rate, and a thermometer placed at the inlet and a second at the outlet allow of taking the difference of temperature and of watching this so that it will be nearly constant. In the same view are seen the two oil-ring bearings, and on the left is the device for making the coupling with the dynamo shaft.

Turning to the practical results which are to be obtained with this apparatus, these are to be classed under two main heads, first the amount of wear of metals, and second the work absorbed in the friction. As regards the wear of metals, the following experiment will show how the method is used. In different forms of testing machines for metals such as for breaking strains, etc., it is customary to work to a much higher point than is required in actual practice. Such is also the case here, and the wear of the sample is given at a much more rapid rate than is occasioned in ordinary cases, seeing that the steel disk has a diameter of 320 millimeters or a periphery of one meter (3.28 feet). As its speed can be made to reach 3,200 revolutions per minute, this gives a peripheral speed of 3,200 meters per minute or 53 meters (174 feet) per second, which is far above what usually occurs in machines. On the other hand, the pressure can be given a much higher figure than for ordinary cases. It is found best in practice to use a test piece which is made of a cylinder of the desired metal about 10 millimeters (0.39 inch) in diameter. At the working part the diameter is reduced to 5.65 millimeters (0.22 inch) so as to give a standard surface of 25 square millimeters (0.039 square inch), this being easier to use in calculations. The pressure upon the test bar can be made as high as 33 kilogrammes (73 pounds) or 1.5 kilogrammes (3.31 pounds) per square millimeter (about 200 pounds per square inch). The piece is held in a standard mandrel which fits exactly into the upper part of the chamber, so that there will be no leakage of oil and no vibration in this part. The disk is made of the hardest steel obtainable and the kind which shows the least friction, so that its friction can be estimated at practically zero in comparison with the test piece. In order to obtain a reasonable amount of wear of the tested metal, the machine must be operated for a long time, even with the above high rotation of the disk. Thus an experiment may need to last fifty hours, that is, five days at ten hours a day, corresponding to ten million revolutions of the disk.

Temperature is a factor which will alter exact measurements, and it is found that a difference of 15 deg. C. (59 deg. F.) from the surrounding air will cause a difference of 1/100 millimeter (0.00039 inch). The measurement should not be begun before the water flow has arrived at a constant rate so that the temperature is constant while the disk is revolving. The surface of the test piece should be worn down to a curve so as to fit upon the disk over the whole surface of the former. The work done by friction can be found by measuring the work done by the electric motor in the usual way, by taking the readings of the voltmeter and ammeter. Again, the heating of the water shows the energy absorbed, and by taking the initial and final temperatures with the two thermometers while the rate of flow is measured, we have a check measure. The friction of the disk in the oil, which takes a greater part of the energy, must first be found and deducted from the result.

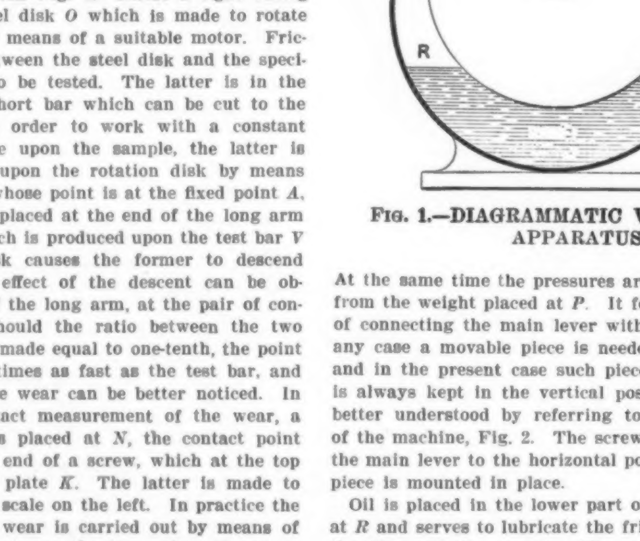


FIG. 2.—SIDE ELEVATION.

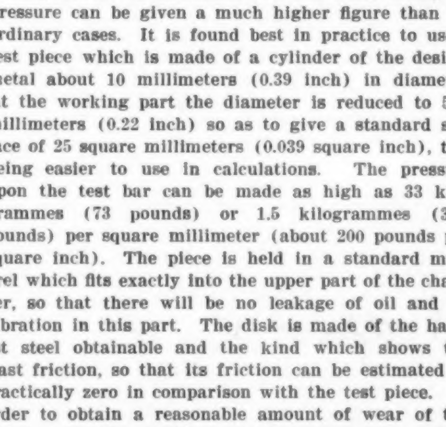


FIG. 3.—CROSS SECTIONAL VIEW.

THE MAKING OF HANDWRITING.*

IS HANDWRITING INHERITED?

BY C. AINSWORTH MITCHELL, B.A. (OXON.), F.I.C.

HANDWRITING is an inheritance from one's ancestors modified more or less by one's own individuality and by external influences. These distinctive modifications form the marks by which we can, as a rule, at once recognize a particular handwriting, for they are usually as characteristic of a man as are his little mannerisms of speech and gait. Even the frequent alterations that may be observed in the writing of certain individuals are indicative of character.

It does not, however, come within the scope of the present paper to discuss to what extent handwriting may indicate character, but rather to deal with the various psychological factors that tend to modify writing, and to accentuate the differences in two or more handwritings inherited from the same ancestors.

With regard to the inheritance of handwriting there

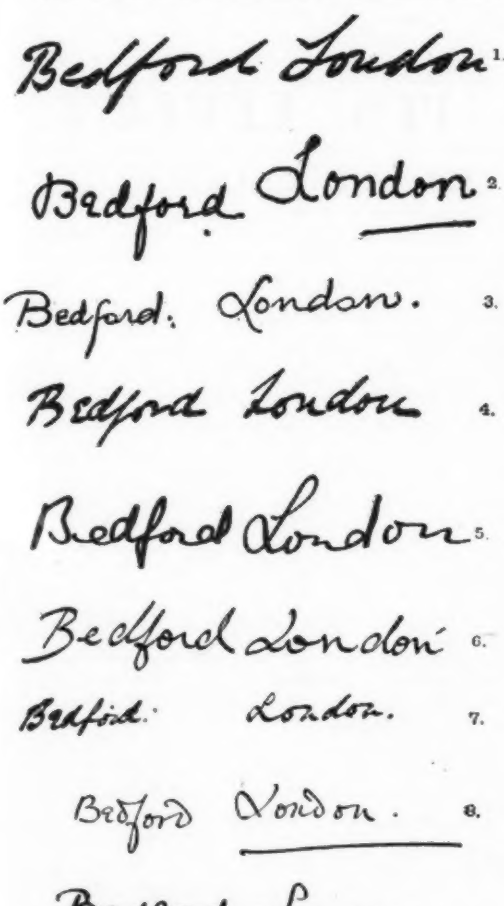


FIG. 1.—INHERITED TRAITS IN HANDWRITING.

can be no doubt. Instances of close resemblances between the writings of the members of one and the same family will readily occur to everyone. A particular slope in the writing or a mode of looping the letters or of forming certain words may be passed on for several generations, especially when they originate from a man or woman of pronounced individuality.

It is, of course, almost impossible to decide from which ancestors all the inherited features in one's handwriting may have been derived, just as it is difficult to trace the origin of certain obviously inherited traits in one's character. It is hardly safe to generalize from even a considerable number of isolated instances, but without going so far as to say that such is the rule, it is yet a remarkable fact that there is frequently a tendency for the sons to inherit certain characteristics in the father's handwriting, and for the daughters' writing to resemble more closely that of their mother than that of their father.

The words (Fig. 1) written by the members of one family afford a typical illustration of this tendency. The first two lines show the respective handwritings of the father and mother. The third, fifth, eighth, and ninth lines were written by their daughters, and the fourth, sixth, and seventh lines by their sons.

It will be noticed, among other points of resemblance, that the bold characteristic looping of the letter L in the mother's handwriting is reproduced more or less closely in the writing of all the daughters, while the sons form the same letter with a small loop

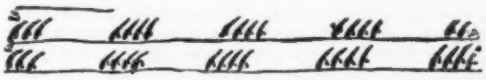


FIG. 2.—A CASE OF AGRAPHIA.

as in the word written by their father. The angles at which the different words are written also show the effect of this parallel heredity, as it might be termed.

While possessing such points of resemblance obviously inherited from the parents' handwriting, the writing of each of the children also shows characteristics that distinguish it from the writings of the others—characteristics partly inherited from other ancestors and partly the result of environment.

We usually speak of *hand*-writing, though the hand is only the trained instrument of a special area in the brain commonly termed the writing center, which may express itself by other means than the hand. Years ago it was demonstrated by Dr. Preyer that the *foot*-writing of a man who had lost both his hands showed the same characteristics as his former handwriting. It has also been found that the words written with a pencil held in the mouth or in the bend of the knee will show indications of the distinctive features of the handwriting of the same individual.

This writing center is not identical with the speech center in the brain, for the power of writing may be retained after total loss of speech; or a man may suddenly lose his power of forming letters, though still able to speak, as was the case with a patient of Prof. Lombroso, whose attempts at writing are shown in Fig. 2. Yet the fact that aphasia is frequently associated with agraphia points to a close relationship between the two areas.

This is strikingly illustrated by a case recorded by Holder of a man who, after having lost his power of speech through a paralytic seizure, gradually regained it with the exception of the sounds of *f*, *l* and *r*, which he always subsequently omitted in speaking. He was also unable to write the same three letters and replaced them by strokes.

Whether the writing center is a large diffused area or is small and circumscribed is unknown, but it appears to be bilateral and to have its seat in both hemispheres of the brain. Thus, in cases of paralysis of the right hand through injury to the left side of the brain, the left hand is readily trained to write.

The phenomenon of mirror writing points to the same conclusion of the duality of the writing center. This backward writing is not uncommon with weak-minded or neurasthenic children, and is also a frequent result of the first attempts of perfectly healthy children to write with the left hand. Often at the close of a writing lesson a wearied child will involuntarily write some of the capital letters, especially E, backward.

An instance of mirror writing is shown in Fig. 3. This was done by a girl of 14, who lives in an English village. Though quick enough in her talk and at play, she is excessively dull at school, and can barely read. When told to write anything, she holds her pencil in the left hand and slowly forms each letter backward from right to left. It is only with the utmost difficulty that she can manage to write a few words forward in the ordinary way.

It has been found by Dr. Preyer that most men who have written much with the right hand produce

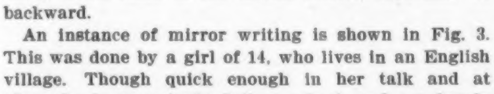


FIG. 3.—MIRROR WRITING.

mirror writing with the left hand when they attempt to write with both hands simultaneously. The same thing has been observed in cases where a man has succeeded in writing with both feet at once, the characters formed by the left foot being reversed.

Both agraphia and mirror writing, however, are pathological in character, and cannot be included among the ordinary influences that contribute to the making of normal handwriting.

Writing may be regarded as normal when the thoughts of the writer are centered upon what is being written, and without a mental side glance at the form of the writing itself. In the latter case various psychological influences may cause the writing to deviate more or less from the normal. For example, the handwriting of an artist may at different periods show marked variations, especially in the form of the capital letters, for the artist is particularly prone to keep before his eye the decorative effect of his letters and words, and to be constantly making experimental changes in his writing.

In like manner handwriting is often influenced to a considerable extent by subconscious memories of the writing of other people, especially of those whom the writer tries to imitate in other respects. In some individuals this unintentional imitation of other handwriting is so pronounced that they are unable to answer any letter without its character having some effect upon their own writing.

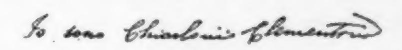


FIG. 4.

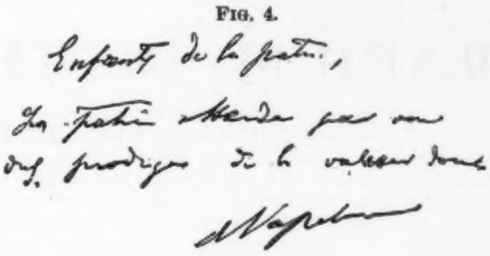


FIG. 5.

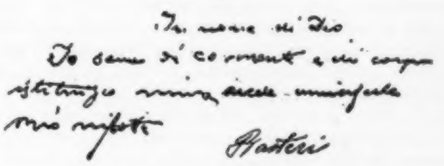


FIG. 6.

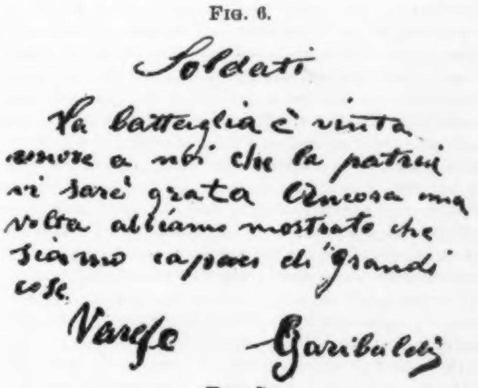


FIG. 7.

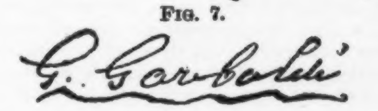


FIG. 8.

Conscious imitation is a still more frequent influence upon the form of writing, and some of its effects may become fixed characteristics. Instances of this are to be seen in the "good" writing of the old-fashioned writing master, whose ideal was the copperplate engraving of the visiting card with its thick downstroke and thin upstroke, and absolute regularity of letter; in the pointed Italian writing taught generally in mid-Victorian ladies' schools; in the Civil Service "hand" set as a standard for securing marks in examination; and in modern commercial handwriting now rapidly giving place to the typewriter.

In all such cases as these, where prolonged attention has been given to the form of every letter, the handwriting is largely an acquired one, though in time it tends through habit to become the normal writing. Where there has been no conscious imitation or experimental alteration and but little unconscious imitation, certain distinctive features in a writing may persist for a very long period. Thus, the angle at which the writing slopes may remain practically the same for years, or the form of a particular flourish beneath a signature will repeat itself almost exactly time after time, and even the absence of a flourish may become a significant characteristic.

Emotional influences often have some effect upon handwriting, though the alterations thus produced are only slight and temporary. Thus, a man weighed down

* Knowledge and Scientific News.

with overwhelming grief will often write in smaller characters than usual, while violent anger will find its expression in the more vigorous cross strokes of the "t's," the heavier dotting of the "i's," and the thickness of the flourish to a signature. On the other hand, slight changes caused by long-continued depression resulting from illness may leave permanent traces upon handwriting.

There are many such temporary influences tending to modify handwriting, but none is more remarkable or affords a better proof of the way in which written characters vary with the condition of the mind than the effect of hypnotic suggestion.

The experiments of Profs. Lombroso and Richet have proved that a suggested change of personality under hypnotic influence is accompanied by an appropriate alteration in the handwriting of the subject. Thus, a young hysterical girl, when hypnotized, under the suggestion that she was a child wrote in childish characters.

Still more striking were their experiments upon a Trieste student, Chiarioni Clementino, who, within little more than an hour, was made to assume successively the characters of a child, of a peasant woman, of Napoleon, of Garibaldi, of a clerk, and of an old man of 90. He was made to write some words in each of his assumed characters, and the writings not only differed to a marked extent from his normal handwriting, but also had characteristics suggestive of the type of individual he was temporarily personating.

The present writer is greatly indebted to Prof. Lombroso for permission to reproduce the results of some of these experiments. Fig. 4 shows the normal signature of the hypnotized student, Fig. 5 his writing as Napoleon, Fig. 6 as the old man of 90, and Fig. 7 as Garibaldi.

The handwritings of the suggested Napoleon and Garibaldi were quite different from the writing of the real individuals, though it is interesting to note that there is some attempt to form the letters of Garibaldi's signature in the same way as in the genuine signature (Fig. 8).

In a private communication to the present writer, Prof. Lombroso states that it is quite possible for the hypnotized student to have been familiar with the signature of Garibaldi exhibited in different museums in Italy. Or, again, the hypnotizers may have had their thoughts upon the form of the genuine signature while the student was writing the suggested version of it. Further experiments in this direction would be instructive.

It has been observed by Dr. Preyer that certain individuals, when under hypnotic influence, have better handwriting than they have in their normal condition, whereas in the case of other subjects the letters are childish and badly formed.

It is even possible to make them omit by suggestion particular letters from each word they write, "Europe," for instance, becoming "Urop," and so on; while by further suggestion they will again make use of the missing letters.

The fact that handwriting may be completely altered under the influence of hypnotism is not only of great scientific interest, but may also have a practical bearing on the results of legal cases in which handwriting is concerned.

It was pointed out some years ago by Dr. Bianchi that hysterical women are particularly prone to write anonymous letters, and it is well known that such women are readily responsive to hypnotic suggestion.

Facts such as these suggest how necessary it may often be to take into account the possibility of hypnotic influence before deciding upon the authorship of a given piece of writing.

To what extent should a man be held responsible for what he has written as the result of hypnotic suggestion from another person? The answer will obviously depend upon whether he was the dupe or the willing instrument of the hypnotizer. In the latter case it will be difficult to prove that the writing is his, for it will be probably very different from his ordinary handwriting. In fact, is it his?

In the present state of knowledge the average jury of to-day is scarcely competent to deal with a case of criminal libel in which such delicate points as these might be raised.

RADIUM IN THE EARTH AND ITS EFFECT.*

RADIO-ACTIVE DEPOSITS AND THE INSTABILITY OF THE CRUST.

BY PROF. JOHN JOLY, M.A.

The history of mountain building has repeated itself many times; ages of sedimentation, with attendant sinking of the crust in the area of deposition, then upheaval, folding up of the great beds of sediment, and even their over-thrusting for many miles. So that the mountain ranges of the world are not constituted from materials rising from below, save in so far as these may form a sustaining core, but of the slowly accumulating deposits of the ages preceding the upheaval.

The thickness of collected sediments involved in these great events is enormous, and although uncertainty often attends the estimation of the aggregate depths of sedimentation, yet when we consider that unconformities between the deposits of succeeding eras represent the removal of vast masses of sediment to fresh areas of deposition, and often in such a way as to lead to an underestimate of the thickness of deposit, the observations of the geologist may well indicate the minor and not the major limit. Witness the mighty layers of the Huronian, Animikean, and Keweenawan ages where deposits measured in miles of thickness are succeeded by unrecorded intervals of time, in which we know with certainty that the tireless forces of denudation labored to undo their former work. Each era represents a slow and measured pulse in the earth's crust, as if the overloading and sinking of the surface materials induced the very conditions required for their re-elevation. Such events, even in times when the crust was thinner and more readily disturbed than it is now, must have taken vast periods of time. The unconformity may represent as long a period as that of accumulation. In these Proterozoic areas of America, as elsewhere on the globe and throughout the whole of geological history, there has been a succession in time of foldings of the crust always so located as to uplift the areas of sedimentation, these upheavals being sundered by long intervals during which the site of sedimentation was transferred and preparation made for another era of disturbance. However long deferred there seems to be only the one and inevitable ending, inducing a rhythmic and monotonous repetition surely indicative of some cause of instability attending the events of deposition.

The facts have been impressively stated by Dana: "A mountain range of the common type, like that to which the Appalachians belong, is made out of the sedimentary formations of a long preceding era; beds that were laid down conformably, and in succession, until they had reached the needed thickness; beds spreading over a region tens of thousands of square miles in area. The region over which sedimentary formations were in progress in order to make, finally, the Appalachian range, reached from New York to Alabama, and had a breadth of 100 to 200 miles, and the pile of horizontal beds along the middle was 40,000 feet in depth. The pile for the Wahsatch Mountains was 60,000 feet thick, according to King. The beds for the Appalachians were not laid down in a deep ocean, but in shallow waters, where a gradual subsidence was in progress; and they at last, when ready for the genesis, lay in a trough 40,000 feet deep, filling the trough to the brim. It thus appears that epochs of mountain making have occurred only after long intervals of quiet in the history of a continent." The generally observed fact that the deposition of sediments in some manner involves their ultimate upheaval has at various times led to explanations being offered. I think I am safe in saying that although the primary factor, the compressive stress in a crust which has ceased to fit the shrinking world within it, has probably been correctly inferred, no satisfactory explanation of the connection between sedimentation and upheaval has been advanced. The mere shifting upward of the isogeotherms into the deposits, advanced as a source of local loss of rigidity by Babbage and Herschel, need not involve any loss so long as the original distance of the isogeotherms from the surface is preserved.

We see in every case that only after great thicknesses of sediments have accumulated is the upheaval brought about. This is a feature which must enter as an essential condition into whatever explanation we propose to offer.

Following up the idea that the sought-for instability is referable to radio-thermal actions,* we will endeavor to form some approximate estimate of the rise of temperature which will be brought about at the base of such great sedimentary accumulations as have gone toward mountain building, due to the radium distributed throughout the materials.

The temperature at the base of a feebly radio-active layer, such as an accumulation of sediments, is defined in part by radio-active energy, in part by its position relative to the normal isogeotherms, whether these latter are in turn due to or influenced by radio-thermal supplies or not. It is convenient, and I think allowable, to consider these two effects separately, and deal with them as if they were independent, the resultant state being obtained by their summation.

In dealing with the rise of temperature at the base of a radio-active layer we arrive at an expression which involves the square of the depth. This is a very important feature in the investigation, and leads to the result that, for a given amount of radium, diffuse distribution through a great depth of deposit gives rise to a higher basal temperature than a more concentrated distribution in a shallower layer.

But this will not give us the whole effect of such a deposit. Another and an important factor has to be taken into account. We have seen that the immediate surface rocks are of such richness in radium as to preclude the idea that a similar richness can extend many miles inward.

Now, it is upon this surface layer that the sediments are piled, and as they grow in thickness this original layer is depressed deeper and deeper, yielding under the load until at length it is buried to the full depth of the overlying deposit. This slow and measured process is attended by remarkable thermal effects. The law of the increase of temperature with the square of the depth comes in, and we have to consider the temperature effect not merely at the base of the deposited layer, but that due to the depression and covering over of the radium-rich materials upon which the sediments were laid down.

The table which follows embodies an approximate statement of the thermal results of various depths of deposit supposed to collect under conditions of crustal temperature such as prevail in this present epoch of geological history:

Thickness of Sedimentary Deposit.	Resulting Rise of Isogeotherms.	Weakening of Earth's Crust as Defined by the Rise of the Geotherm at 40 Kilometers.
Kilometers.	Kilometers.	Kilometers.
6	7.4	40 to 32.6
8	10.2	40 to 29.8
10	13.3	40 to 26.7
12	16.7	40 to 23.3
14	20.4	40 to 19.6

I have deferred till this place an account of the steps followed in obtaining the above results. It is clearly impossible, within the limited space allotted to me, to make these quite clear. It must suffice here merely to explain the significance of the figures.

The first column gives the depth of sedimentary deposit supposed to be laid down on the normal radio-active upper crust of a certain assumed thickness and radio-activity. From the rise of temperature which occurs at the base of this crust (due to the radio-activity, not only of the crust, but of the sediments) the results of the second column are deduced, the gradient or slope of temperature prevailing beneath being derived from the existing surface gradients corrected for the effects of the radio-thermal layer. The third column is intended to exhibit the effect of this shift of the geotherms in reducing the strength of the crust. I assume that at a temperature of 800 deg. the deep-seated materials lose rigidity under long-continued stress. The estimated depth of this geotherm is, on the assumptions, about 40 kilometers. The upward shift of this geotherm shows the loss of strength. Thus in the case of a sedimentary accumulation of 10 kilometers the geotherm defining the base of the rigid crust shifts upward by 13 kilometers, so that there is a loss of effective section to the amount of 30 per cent.

As regards the claims which such figures have upon our consideration, my assumptions as to thickness and radio-activity of the specially rich surface layer are, doubtless, capable of considerable amendment. It will be found, however, that the assumed factors may be supposed to vary considerably, and yet the final results prove such as, I believe, cannot be ignored. Indeed, those who are in the way of making such calculations, and who enter into the question, will find that my assumptions are not specially favorable, but are, in fact, made on quite independent grounds;

* Abstracted from a paper read before the British Association for the Advancement of Science.

* Discussed in previous portions of this paper and published in the Scientific American Supplement.

again, a certain class of effects has been entirely left out of account, effects which will go toward enhancing, and in some cases greatly enhancing, the radiothermal activity. I refer to the thickening of the crust arising from tangential pressure, and, at a later stage, the piling up and overthrusting of mountain building materials. In such cases the temperature of the deeper parts of the thickened mass must still further rise under the influence of the contained radium. These effects take place, indeed, only after yielding has commenced, but they add to the element of instability which the presence of the accumulated radioactive deposits occasions, and doubtless increase thermal metamorphic actions in the deeper sediments, and result in the refusion of rocks in the upper part of the crust.*

The effect of accumulated sediment is thus necessarily a reduction in the thickness of that part of the upper crust which is capable of resisting a compressive stress. Over the area of sedimentation, and more especially along the deepest line of synclinal depression, the crust of the globe for a period assumes the properties belonging to an earlier age, yielding up some of the rigidity which was the slow inheritance of secular cooling. Along this area of weakness—from its mode of formation generally much elongated in form—the stressed crust for many hundreds, perhaps thousands, of miles finds relief, and flexure takes place in the only possible direction; that is, on the whole upward. In this way the prolonged anticline bearing upward on its crust the whole mass of deposits is formed, and so are born the mountain ranges in all their diversity of form and structure.

We have in these effects an intervention of radium in the dynamics of the earth's crust, which must have influenced the entire history of our globe, and which, I believe, affords a key to the instability of the crust. For after the events of mountain building are accomplished, stability is not attained, but in presence of the forces of denudation the whole sequence of events has to commence over again. Every fresh accession of snow to the firn, every passing cloud contributing its small addition to the torrent, assists to spread out once more on the floor of the ocean the heat-producing substance. With this rhythmic succession of events appear bound up those positive or negative movements of the strand which cover and uncover the continents, and have swayed the entire course of evolution of terrestrial life.

Oceanic Deposits.—The displacements of the crust which we have been considering are now known to be by no means confined to the oceanic margins. The evidence seems conclusive that long-continued movements have been in progress over certain areas of the sea floor, attended with the formation of those numerous volcanic cones upon which the coral island finds foundation. Here are plainly revealed signs of instability and yielding of the crust (although, perhaps, of minor intensity) such as are associated with the greater movements which terminate in mountain building. I think it will be found, when the facts are considered, that we have phenomena continuous with those already dealt with, and although the conditional element of a sufficient sedimentary accumulation must remain speculative, the evidence we possess is in favor of its existence.

One of the most interesting outstanding problems of deep-sea physiography is that of the rates of accumulation of the several sorts of deposit. In the case of the more rapidly collecting sediments there seems no serious reason why the matter should not be dealt with observationally. I hope it may be accomplished in our time. For my present purpose I should like to know what may or may not be assumed in discussing the accumulation of radio-active sediments on the ocean floor.

As regards the rate of collection of the non-calcareous deposits, the nearest approach to an estimate is, I think, to be obtained from the exposed oceanic deposits of Barbados. In the well-known paper of Jukes Brown and Harrison† on the geology of that island, it is shown that the siliceous radiolarian earths and red clays aggregate to a thickness of about 300 feet. These materials are true oceanic deposits, devoid of terrigenous substances. They collected very probably during Pliocene and, perhaps, part of Pleistocene times. Now, there is evidence to lead us to date the beginning of the Pliocene as anything from one million to three million years ago. The mean of these estimates gives a rate of collection of 5 millimeters in a century. This sounds a very slow rate of growth, but it is too fast to be assumed for such deposits generally. More recent observations might, indeed, lead us to lengthen the period assigned to the deposition of these oceanic beds; for if, following Prof. Spencer,‡ we ascribe their deposition to Eocene times, a less definite time-interval is indicated; but the rate could hardly have been less than 3 millimeters in a century. The site of the deposit was probably favorable to rapid growth.

We have already found a maximum limit to the average thickness of true oceanic sediments; and such as would obtain over the ocean floor if the rate of collection was everywhere the same and had so continued during the past. If there is one thing certain, however, it is that the rates of accumulation vary enormously. The 1,200 or 1,500 feet of chalk in the British Cretaceous, collected in one relatively brief period of submergence, would alone establish this. Huxley inferred that the chalk collected at the rate of 1 inch in a year. Sollas showed that the rate was more probably 1 inch in forty years. Sir John Murray has advanced evidence that in parts of the Atlantic the cables become covered with Globigerina ooze at the rate of about 10 inches in a century. Finally, then, we must take it that the fair allowance of one-seventh of a mile may be withheld in some areas and many times exceeded in others.

Now it is remarkable that all the conditions for rapid deposition seem to prevail over these volcanic areas of the Pacific from which ascend to the surface the coral islands—abundant pelagic life and comparatively shallow depths. Indeed, I may remind you that the very favorable nature of the conditions enter into the well-known theory of coral island formation put forward by Murray.

The islands arise from depths of between 1,000 and 2,000 fathoms. These areas are covered with Globigerina ooze having a radio-activity of about 7 or 8. The deeper-lying deposits around—red clay and radiolarian ooze—show radio-activities up to and more than 50. From these no volcanic islands spring.

These facts, however, so far from being opposed to the view that the radio-activity and crustal disturbance are connected, are in its favor. For while those rich areas testify to the supply of radio-active materials, the slow rate of growth prevailing deprives those deposits of that characteristic depth which, if I may put it so, is of more consequence than a high radio-activity. For the rise in temperature at the base of a deposit, as already pointed out, is proportional to the square of the thickness; in reality the dilution of the supplies of uranium which reach the calcareous oozes flooring the disturbed areas is a necessary condition for any effective radio-thermal actions.

It might appear futile to consider the matter any closer where so little is known. But in order to give an idea of the quantities involved I may state that, if my calculations are correct, a rate of deposit comparable with that of the chalk prevailing for ten million years would, on assumptions similar to those already explained when discussing the subject of mountain building, occasion a rise of the deeper isogeotherms by from 20 to 30 per cent of their probable normal depth.

In making these deductions as to the influence of radium in sedimentary deposits, I have so far left out of consideration the question of the time which must elapse in order that the final temperature rise in the sediments must be attained. The question we have to answer is: Will the rate of rise of temperature due to radium keep pace with the rate of deposition, or must a certain period elapse after the sedimentation is completed to any particular depth, before the basal temperature proper to the depth is attained?

The answer appears to be, on an approximate method of solution, that for rates of deposition such as we believe to prevail in terrigenous deposits—even so great as 1 foot in a century, and up to depths of accumulation of 10 kilometers and even more—the heating waits on the sedimentation. Or, in other words, there is thermal equilibrium at every stage of growth of the deposit; and the basal temperature due to radioactive heating may at any instant be computed by the conductivity equation. For accumulations of still greater magnitude the final and maximum temperature appears to lag somewhat behind the rate of deposition.

From this we may infer that the great events of geological history have primarily waited upon the rates of denudation and sedimentation. The sites of the terrigenous deposits and the marginal oceanic precipitates have many times been convulsed during geological times because the rates of accumulation thereon have been rapid. The comparative tranquility of the ocean floor far removed from the land may be referred to the absence of the inciting cause of disturbance. If, however, favorable conditions prevail for such a period that the local accumulations attain the sufficient depth, here, too, the stability must break down and the permanency be interrupted.

Upheaval of the ocean floor, owing to the laws of deep-sea sedimentation, should be attended with effects accelerative of deposition—a fact which may not be without influence. But although ultimately sharing the instability of the continental margins, the cycle of change is tuned to a slower periodicity. From the operation of these causes, possibly, have come and gone those continents which many believe to have once replaced the wastes of the oceans, and which with all their wealth of life and scenic beauty have disappeared so completely that they scarce have left a wreck behind. But those forgotten worlds may be again restored. The rolled-up crust of the earth is still rich in energy borrowed from earlier times, and the slow but mighty influences of denudation and deposition are forever at work. And so, perchance, in some remote age the vanished Gondwána Land, the lost Atlantis, may once again arise, the seeds of resurrection even now being sown upon their graves from the endless harvests of pelagic life.

* Prof. C. Schmidt (Basel) has recently given reasons for the view that the Mesozoic schists of the Simplon at the period of their folding were probably from 15,000 to 20,000 meters beneath the surface ("Ec. Geol. Helvetiæ," vol. ix, No. 4, p. 500). As another instance consider the compression of the Laramide range (Dawson, Bull. Geol. Soc. Am., xii, p. 87).

† O. J. G. S., xlviii., p. 210.

‡ *Ibid.*, lviii., p. 354, *et seq.*

THE ORIGIN OF THE MOON.*

In his inaugural lecture delivered in Columbia University, November 3rd, 1908, Dr. Albrecht F. K. Penck, the Kaiser Wilhelm "Umtausch" Professor, spoke in part as follows concerning the geographical and geological similarities between the eastern coast of North America and the western coast of Europe:

"These similarities between Europe and peninsular North America are not merely superficial ones. In a very remarkable way, these two sides of the Atlantic repeat the same structural features; there is an astonishing symmetry, as Eduard Suess has shown so clearly. The northeast of Canada and Labrador on one side, and Scandinavia with Finland, the region of Feno-Scandia, on the other, are both composed of the oldest rocks we know of. These have a very complicated structure, being intruded with many eruptive rocks, and in a secondary way only, the surface features of the above regions are dependent on their structure. Both regions had already been leveled down before Cambrian times, and they sink gently down under a cover of horizontal Paleozoic strata. Both were called by Suess shields. The resemblance between these shields is the more conspicuous because both were covered during the last ice age by a glaciation which molded their surface in a similar way. In Sweden and Finland we find the same rounded glaciated surface, the same numerous lakes, as in Canada, both regions of the earth claiming to be the land of the many thousand lakes. At the border of both regions the horizontal Paleozoic strata begin with an escarpment which is pronouncedly developed south of Lake Erie and south of the Gulf of Finland, called here the 'glint,' and we shall keep this expression to designate similar escarpments. These strata continue far into the interior of Eurasia, and they do the same in North America."

And again:

"It is very interesting to see how the Appalachian region ends at Newfoundland, forming the projecting eastern corner of North America, and just opposite in south Ireland, in south Wales, in Cornwall, and in Brittany the belt of the old Hercynian Mountains of Europe begins. One seems to be the continuation of the other, and such an excellent geologist as Marcel Bertrand maintained that *we have here to deal with the two ends of one very extensive belt of mountains which extended through the North Atlantic Ocean. But we must not forget that the missing link between both ends of these supposed mountain chains is longer than their known extent.*" (The italics are mine.)

It seems to me that these and other parts of his lecture throw an interesting light on the theory of the moon's terrestrial origin. In brief, the theory is that when the earth had cooled from its molten condition sufficiently to have a crust of solidified matter something like thirty miles thick over its entire surface, it was revolving so rapidly that gravitational attraction and centrifugal force practically balanced each other. For some reason, perhaps some vast and sudden cataclysm, a large portion of this crust was thrown off the earth, and by tidal action was forced gradually outward in a spiral path. In order to form the moon, a mass of this crust about thirty miles thick and of area nearly equal to the combined areas of the present oceans on the earth must have been thrown off. It is supposed that this immense amount of crust was largely taken from the present basin of the Pacific, and that the remaining parts of the earth's crust, while it still floated on a liquid interior, split along an irregular line into two pieces which floated apart, and the gap between these two parts was later filled with the waters of the Atlantic. Many reasons are advanced for the probability of this theory—the fact that the two coasts of the Atlantic have the same contour, the identity between the density of the moon and that of the earth-crust, etc. Prof. Penck is evidently not considering this theory at all in his lecture, and yet it seems that what he, approaching the problem from a geographical standpoint, has to say about it, lends a greater probability to the theory. As he says, the Appalachian region ends at Newfoundland, about the latitude of 50 deg. north, and just opposite, in Great Britain, on the same latitude, the same region seems to continue. If the theory of the terrestrial origin of the moon outlined above, be accepted, we can explain this phenomenon much more simply than did Bertrand, and need not suppose the range to extend across the bed of the Atlantic at all.—Andrew H. Patterson.

* Science.

ENGINEERING NOTES.

It is stated by the United States engineer officer in charge of the dredging operations in connection with the deepening of the Baltimore channel, that its depth now existing to the sea, with the exception of the western half crossing York Spit, near the mouth of the Chesapeake Bay, is 35 feet, with a width of 600 feet. Congress has made an appropriation of $34,000 for the completion of the work. It is intended to make the channel wider in the immediate neighborhood of Fort McHenry to provide anchorage for ocean-going craft.

An example of an apartment house in reinforced concrete is to be found in Genoa, Italy, and it is built entirely of this material. It covers an area of 2,700 square yards with but 350 square yards taken by the inner court, being a seven-story building with cellar. A large building recently erected on the Continent in ferro-concrete is the paper factory at Oberlenningen, Germany. It is a separate structure which is used for handling the paper paste, and is erected beside the other buildings, containing machine shops, boiler room and water tanks. This building is one of the most recent examples of this construction.

R. L. Humphrey describes in the Engineering News a vertical hydraulic press which will test columns up to 65 feet long and about 6 feet square. The load is weighed with a contract accuracy of 1/3 per cent for loads over 100,000 pounds by weighing with the ordinary multiple lever arrangement the pressure on a piston of 1/80 of the area of the main cylinder, and connected with it. Oil pressure is applied by a triple-plunger pump with a 15-horse-power motor, which when operated at its slowest speed supplies sufficient oil through a needle valve to compensate for any leakage. The main ram has a movement of 24 inches at speeds of from 1/60 to ½ inch per minute. The machine is being made by Olsen for the Structural Materials Testing Laboratories of the U. S. Geological Survey.

A consular report for 1908 dealing with the consular district of Chicago states that the railways have done less building than in any year since 1898, the mileage of 1908 being 3,314 miles, which is about 2,000 miles less than in 1907. A great deal of the building has been done in the Western States by the Great Northern, Chicago, Milwaukee and St. Paul, and the Northern Pacific. The building of cars for railways fell off considerably, only 62,669 freight cars and 1,319 passenger cars being built in 1908, as against 161,711 freight and 1,791 passenger cars in 1907. Only 1,182 locomotives were built in 1908, as against 3,482 in 1907. About 900 miles more track were equipped with block signals, and the use of this system is steadily progressing. The year has not been favorable to the railways, for while the cost of carrying on the lines has not seen much change, the earnings have decreased considerably, and with the 2 cents a mile passenger rate which obtains in many sparsely populated districts, extra taxation, and idle cars, many difficulties have faced the managers, but there would seem to be an agreement among them to advance freight rates.

What would appear to be a most important extension of the structural materials investigations which have been carried on by the government for several years has recently been determined upon. These investigations, as is generally known, have had for their object the determination of the nature and extent of the materials available for use in the construction of federal buildings and the manner in which they can be used to obtain maximum efficiency. The proposed extension in this work will include investigations of clays and clay products undertaken by the United States Geological Survey, Technological Branch. The ever-increasing scarcity of wood renders self-apparent the fact that at no distant day a substitute for this most useful material of construction must of necessity be produced. With this necessity in prospect the investigation of clay products is about to be undertaken, and the results will be awaited with keen interest. A full investigation of this material will undoubtedly embrace a consideration of manufacturing problems and it is to be hoped that greater perfection will be made possible by their solution. While there exist beyond question many and undeniably great advantages peculiar to clay products as materials of construction, there have been noted from earliest times certain defects, whose presence can scarcely be detected before use of the material, and the effects of which are ruinously injurious. Probably efflorescence appearing on brickwork has caused more annoyance and expense and marred the appearance of more structures than any other one defect of the material. If the government experts succeed in infallibly overcoming this fault or imperfection without unduly increasing the cost of the material great benefit to the clay products industry will inevitably accrue, and if some form of the material were evolved that could fairly be considered a substitute for wood, the result would be little less than revolutionary.—*American Architect.*

SCIENCE NOTES.

Dr. Robbins, an English writer, calls attention to the development of the jaws of English boys who were taken out of the streets of London and sent into the British navy. He says: "Undoubtedly the important notable improvement in them, next to their superior stature and healthy appearance, was the total change in the shape and expression of their faces. On analyzing this, one finds that it was to be mainly accounted for by the increased growth and improved angle of the lower jaw." The change is due to the rations of "hard tack" and "salt junk" upon which these lads had subsisted.

An English dentist of repute, Dr. Harry Campbell, calls this the "pap" age, because we feed our children largely on "pap." In his opinion the result is adenoids. The good old-fashioned plan of chewing sufficiently hard and dry food to exercise and develop the jaws and teeth seems to have been abandoned in our effete civilization. Our children are now fed on previously-cooked starchy breakfast foods, which may differ in name and flavor, but which agree in two characteristics, namely, that they pander to lazy housekeeping, while requiring very little preparation for the table; secondly, that they require little or no mastication before swallowing. Proper digestion of starchy food must begin in the mouth, and is impossible without complete mastication.

Boneblack and other varieties of charcoal have a greater or less decolorizing action upon liquids. For example, red wine shaken with boneblack and then filtered becomes almost colorless. The cause of the loss of color has been much discussed. It is found that the absorbing power of vegetable charcoals, which contain little ash and no nitrogen, is very small, while charcoal which contains nitrogen possesses an absorbing power which depends neither upon the nature of the ash nor upon the fineness of the charcoal, but solely upon the proportion of nitrogen and hydrogen which it contains. It may be inferred that the absorbing power of animal charcoal is due to the presence of substances containing nitrogen combined with carbon, and this view is confirmed by experiments in the precipitation of various coloring matters by various compounds of nitrogen, such as potassium cyanide, cyanate, sulphocyanate, hydrocyanic acid, etc. Nitrated charcoal made by calcining gelatin or wool has no absorbing effect upon colors, but it acquires great decoloring power on being heated with potassium carbonate. As yet the absorbing power of lampblack, which contains neither ash nor nitrogen, has not been explained.

Yellow fever is transmitted by one kind of mosquito and malaria by another; the tropical disease known as filiariasis is likewise transmitted by a certain species of mosquito; bubonic plague is carried by fleas; the so-called spotted fever of the Rocky Mountain region is caused by the bite of a certain kind of tick, just as the Texas fever is given to cattle by the bite of another species of tick, but the insect credited with carrying the greatest number of the most dreaded diseases is in our midst—the common house fly. This pest, says Dr. R. O. Howard, should rightly be called the "typhoid fly," as the crime of carrying this most dreaded disease has been fastened on this insect beyond question. Dr. Howard's remarks were recently published in the Supplement. This same pest is likewise an active agent in the dissemination of Asiatic cholera, the purulent ophthalmia of the Nile basin, and is a minor factor in the spread of tuberculosis. The pink-eye of the South is transmitted by the minute flies of the genus *Hippelates*, and the sleeping sickness of Africa is carried by a certain biting fly. All physicians agree that great danger of the spreading of contagion lurks in the house fly, and unite in their advice to do everything possible to exterminate the pests as the summer comes on. Because they have become so accustomed to seeing them around, the majority of persons, however, are prone to overlook the many dangers to which the fly daily subjects them, and view it only as a nuisance. The physical formation of the fly is such as to make it a peculiarly well-adapted vehicle for the transmission of contagion. Its feet are hairy and provided with strong power of suction; and thus when it alights on any filth that contains the germs of disease, it is certain to carry away some of those germs and deposit them wherever it next alights. If it lights on the food you are eating or upon an abraded surface of your skin, there is no reason why it should not deposit these germs and subject you to the disease. It requires about six days for the larva of a fly to hatch, and if the places where they breed, usually in stables, or places where animals are kept, are kept clean and disinfected with chloride of lime, little trouble from them will be encountered. Markets and all places where foodstuffs are sold should be kept clear of flies by the means of mechanical fans, and the homes should be screened and every precaution taken to keep the premises clean and not permit breeding places to abound. If every family in a block would take precaution to prevent the accumulation of breeding places for flies, there would soon be no flies in that block. Flies do not travel long distances unless driven by the wind. They are born, live, and die in a restricted zone.

TRADE NOTES AND FORMULÆ.

To Color White Enamel.—This may be effected with the following: Blue: 94 parts white enamel, 6 parts oxide of cobalt. Violet: 95 parts of white enamel, 5 parts manganese. Yellow: 91 parts white enamel, 5 parts Naples yellow. Green: 95 parts white enamel, 5 parts oxide of copper. Pistache green: 92 parts white enamel, 5 parts oxide of copper, 2 parts Naples yellow.

Leonhardi Ink Tablets.—42 parts Aleppo gall nuts and 3 parts of Dutch madder are extracted with a sufficient quantity of warm water; this fluid is then filtered. Dissolve in it 5½ parts of green vitriol and add 2 parts of pyrolignite of iron and 1¼ parts of indigo solution. The mixture is evaporated to dryness at moderate heat and made up into tablets of convenient size. One part by weight of these tablets, dissolved in 6 parts of hot water, gives an excellent writing and copying ink.

Beerit is a material discovered by Sculptor Beer in Paris for the production of castings of the smallest and also of the largest dimensions, the outlines and tracing displaying, in both cases, a sharpness never obtainable with plaster. The casting, in about three hours after being run into the mold, is perfectly hard and complete and but seldom requires working over. Beerit is said to be composed of 100 parts of marble dust, 10 to 25 parts of pulverized glass, and 5 to 10 parts of pulverized, screened lime, mixed with water glass.

A New Paint for Wooden Posts.—Take 50 parts of rosin, 40 parts of finely crushed chalk, 500 parts of fine white and sharp sand, 4 parts linseed oil, 1 part natural red oxide of copper, and 1 part of sulphuric acid. First heat the rosin, the chalk, the sand and the linseed oil in an iron kettle, then add the oxide and carefully introduce the sulphuric acid. Mix all very carefully and apply to the wood, while still hot, with the aid of a stiff brush. If the mixture does not appear to be thin enough, dilute it with some linseed oil. When this coat is cooled and dried it forms a covering as hard as stone, that no moisture will penetrate.

Belt Cement.—I. 5 parts of sulphide of carbon and half a part of oil of turpentine are mixed and therein gradually enough gutta percha dissolved to give the mass a paste-like appearance. The leather parts must then be freed from grease by placing a clean rag on the surface of the leather and standing a hot iron on it. Then both pieces are coated with the cement and exposed to pressure until it has dried. II. Dissolve 1,000 parts of good joiners' glue in 1,500 parts of water, concentrate to syrupy consistency and stir thoroughly into the hot mass 100 parts of Venice turpentine and 5 parts of carbolic acid. After cooling, we have a thick mass, which is cut into cakes ¼ of an inch thick and dried on tin saucers. In two days it is dry and can be placed on the market. The cement is applied to the beveled ends of the leather (belt) after it has been liquefied by the addition of a little vinegar, with the aid of a brush. Then the two ends are subjected to pressure for a quarter of an hour between two iron plates, heated to 87 deg. F. After this process the cemented leather holds securely and cannot be torn apart; it would sooner tear in a fresh place. III. Equal parts of good glue, made from skin trimmings and fish-glue, is softened for 10 hours in water and then boiled with pure tannin, until a uniform, adhesive mass is obtained. The surfaces to be cemented are combed and the cement applied hot. IV. 1 part of finely cut gutta percha is dissolved in the water bath in 10 parts of benzole, then 2 parts of linseed oil varnish stirred into it. V. 1.5 parts of fine cut caoutchouc is dissolved in 10 parts of sulphide of carbon, with application of heat, and 1 part of shellac and 1 part of turpentine added to the solution. The heating must be continued until all the shellac is melted.

TABLE OF CONTENTS.